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NATIONAL DAM SAFETY PROGRAM. DRESSER NUMBER 4 DAM (MO 30474), M--ETC(U)
JUN 79 K B KING, M P FORREST, D R SANDERS DACW43-79-C-0037

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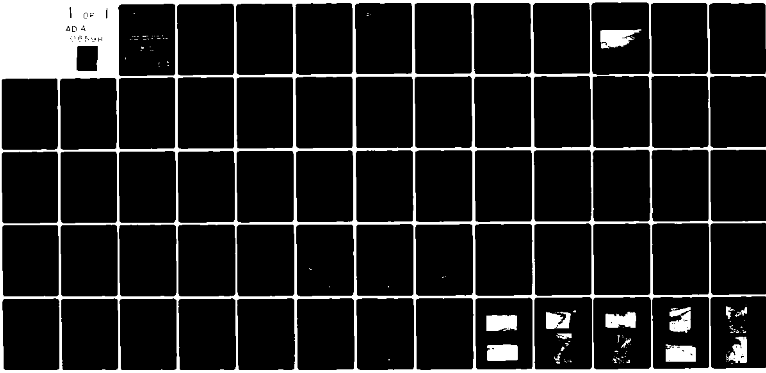

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MISSISSIPPI-KASKASKIA-ST. LOUIS BASIN

DRESSER NO. 4 DAM
WASHINGTON COUNTY, MISSOURI
MO 30474

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
Serving the Army
Serving the Nation

St. Louis District

PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

JUNE 1979

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Kenneth B. /King Michael P. /Forrest
Donald R. /Sanders

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

23 August 1979

SUBJECT: Dresser No. 4 Dam, MO 30474

This report presents the results of field inspection and evaluation of the Dresser No. 4 Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

Dresser No. 4 Dam does not impound water at this time, hence, an hydraulic evaluation of the spillways was not made. It is recommended that such an evaluation be made if the dam is repaired and put into use again.

SIGNED

26 SEP 1979

SUBMITTED BY: ______________________ Chief, Engineering Division ______ Date

SIGNED

26 SEP 1979

APPROVED BY: ______________________ Colonel, CE, District Engineer ______ Date

DRESSER NO. 4 DAM
WASHINGTON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30474

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
INTERNATIONAL ENGINEERING COMPANY, INC.
CONSULTING ENGINEERS
SAN FRANCISCO, CALIFORNIA

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

JUNE 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Dresser No. 4 Dam
State	Missouri
County	Washington
Stream	Tributary to Mill Creek
Date of Inspection	24 March 1979

Dresser No. 4 Dam was inspected by a civil engineer and an engineering geologist from International Engineering Company, Inc. of San Francisco, California. This dam is owned by Dresser Minerals Division of Potosi, Missouri. The purpose of the inspection was to assess the general condition of the dam with respect to safety. The assessment is based on an evaluation of the available data, a visual inspection and an evaluation of the hydrology and hydraulics of the site to determine if the dam poses hazards to human life or property.

The purpose of Dresser No. 4 Dam is to impound tailings from a barite separation and beneficiation operation. The dam completely encircles the impoundment except for a 300-foot wide breach at the north (upstream) end where the structure failed in 1975. The dam cannot retain water in its present state because of this breach in the dam.

Dresser No. 4 Dam was inspected using the "Recommended Guidelines for Safety Inspection of Dams" furnished by the Department of the Army, Office of the Chief of Engineers. Based on these Guidelines, this dam is classified as large. The U.S. Corps of Engineers has classified it as having a high downstream hazard potential to indicate that failure of this dam could threaten life and property. The damage zone, estimated by the U.S. Corps of Engineers, extends about 6 miles downstream of the dam. Several dwellings, low-water bridges and railroad bridges are within this distance. Also, Lower Dresser No. 4 Dam (I.D. 31123) is immediately downstream of this dam.

Since the embankment cannot retain water, the overtopping potential of the embankment was not analyzed. Instead, studies were made to estimate the amount of flow that could occur in the diversion ditch (located to the west and south of the impoundment) under different flood conditions. It was calculated that the diversion ditch could pass a 100-year flood (a flood having a 1 percent chance of being equalled or exceeded in any 1 year) probably without significant erosion of the ditch or adjacent embankment toe. However, it was estimated that the ditch cannot pass 50 percent of the Probable Maximum Flood (PMF) without significant erosion of the ditch and adjacent embankment materials. The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible in the

region. Erosion protection should be provided in the diversion ditch and it should be adequate to withstand the peak discharge velocity resulting from the PMF so that significant erosion of the ditch and adjacent embankment will not occur. The PMF was selected because Lower Dresser No. 4 Dam (intermediate size) is located immediately downstream of Dresser No. 4 Dam. Erosion could cause sediment to be deposited in the reservoir formed by Lower Dresser No. 4 Dam, thus causing a decrease in its storage capacity.

The soft soils at the downstream toe of the dam at the south end of the impoundment could adversely affect the stability of the embankment. The excavation of gravels from the dam has reduced the stability of the dam at the east section of the impoundment. The excavation of gravels from the embankment should be stopped so that the stability of the embankment and crest elevation would not be reduced.

Seepage and stability analyses of the dam are not available. These studies should be performed by a professional engineer experienced in the design and construction of tailings dams and should be made a matter of record.

An inspection and maintenance program should be initiated. Periodic inspections should be made and documented by qualified personnel to observe the performance of the dam and diversion ditch.

It is recommended that the owner take action to correct the deficiencies described.

Kenneth B. King

Kenneth B. King, P.E.

Michael P. Forrest

Michael P. Forrest, P.E.

Donald R. Sanders

Donald R. Sanders, R.G.

VIEW THROUGH BREACH AT NORTH
END OF IMPOUNDMENT OF
DRESSER NO. 4 DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DRESSER NO. 4 DAM
ID NO. 30474

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DRESSER NO. 4 DAM - ID NO. 30474

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspections of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of the Dresser No. 4 Dam be made and authorized International Engineering Company, Inc. to make the inspection.

b. Purpose of the Inspection. The purpose of the inspection was to assess the general condition of the dam with respect to safety, based on available data and visual inspection, to determine if the dam poses hazards to human life or property.

d. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These Guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) Dresser No. 4 Dam is an earthfill dam that is used to impound tailings from a barite separation and beneficiation operation. The dam completely encircles the impoundment except for a 300-foot wide breach at the north (upstream) end where the structure failed in 1975. The dam cannot retain water in its present state because of this breach in the dam. The tailings consist of reddish-brown soft silty clay that are overgrown with vegetation. The tailings were deposited as a slurry in a water environment.

(2) There is no spillway or active outlet pipes at the dam; however, the 300-foot breach effectively acts as an outlet for the impoundment. A diversion ditch conducts water from the north end of the impoundment around the west side of the impoundment to the pond formed downstream by Lower Dresser No. 4 Dam (I.D. 31123).

b. Location. The dam is located in the eastern portion of Washington County, Missouri, as shown in Plate 1. The dam (shown in Plate 2) is located in Sections 10 and 15, Township 38 North, Range 3 East.

c. Size Classification. This dam is greater than 100 feet high and is therefore in the large size classification, according to the "Recommended Guidelines for Safety Inspection of Dams".

d. Hazard Classification. The U.S. Corps of Engineers has classified this dam in the high hazard potential category. The estimated damage zone, as provided by the Corps of Engineers, extends about 6 miles downstream of the dam. Several dwellings, low water bridges and Missouri-Pacific Railroad bridges are within this distance. Also, Lower Dresser No. 4 Dam (I.D. 31123) is immediately downstream of this dam.

e. Ownership. This dam is owned by:

Dresser Minerals Division
Dresser Industries, Inc.
P.O. Box 8
Potosi, MO 63664

f. Purpose of Dam. The purpose of the dam is to impound the tailings from a barite separation and beneficiation operation.

g. Design and Construction History. The exact date that construction began was not known by Mr. A. E. Williams, a representative of Dresser Minerals Division. He did state that Dresser purchased the dam in 1955 from J. R. Dillinger Company, and it may have been constructed in about 1942. The dam failed in August 1975, and it has not been used as an active tailings impoundment since the failure occurred.

h. Normal Operating Procedures. No operating records are known to exist. The facility is inactive in that tailings are no longer conveyed to the impoundment.

1.3 PERTINENT DATA

Field surveys were made by Booker Associates, Inc. of St. Louis, Missouri on 29 March 1979. The survey data is shown in Plates 3, 4 and 5.

a. Drainage Area. 528 acres (Topographic Quadrangle, 7.5 minute series, Tiff, Missouri, 1937)

b. Discharge at Damsite.

(1) Outlet Pipe. There is no active outlet pipe at this dam. Not applicable.

(2) Spillway. There is no spillway at this dam. Not applicable.

(3) Diversion ditch (flowing full) - 2455 cfs.

c. Elevation (Feet above M.S.L.)[1/]

(1) Top of dam - Varies from El. 824.5 to El. 839.5 along the crest roadway. The tailings surface is approximately 6 to 8 feet above the crest roadway at the eastern end of the impoundment because gravel has been excavated from the embankment (see Plate 5B, cross-section at Station 59+00).

(2) Streambed at downstream toe of dam - El. 735 feet ±.

(3) Tailings surface adjacent to dam - Varies from El. 807 at the breach to El. 835 ±.

d. Reservoir. Length of impoundment - 2400 feet from east to west and 1900 feet from north to south. (Aerial photograph, scale: 1 inch equals 1000 feet.)

e. Storage. The tailings surface inside the impoundment slopes downward to the north through the breached section while the natural ground surface slopes downward to the south toward the impoundment forming a topographic depression. The reservoir capacity consists of the storage available in this depression. The average elevation of the ground surface in this depression was assumed to be El. 807. This area was covered with tailings, which were released during the August 1975 failure of the dam. The following storage capacities pertain to the active storage available above El. 807.

(1) Active storage capacity at El. 807 - 0 acre-feet.

(2) Active storage capacity at El. 817 (Max. W. S. elevation resulting from PMF - see Section 5) - 587 acre-feet.

f. Reservoir Surface Area.

(1) Area within impoundment - 74 acres.

[1/] Elevations are based on a reference datum of 825.39 feet M.S.L. at the temporary bench mark (see Plate 3). This elevation was established from the temporary bench mark set at Lower Dresser No. 4 Dam (I.D. No. 31123). The elevation of that bench mark was estimated from the topographic quadrangle.

(2) The following reservoir surface areas pertain to the combined areas within and north of the impoundment above El 807

(a) Surface area at El 807 - 33 acres

(b) Surface area at El. 817 (Max. W. S. elevation resulting from PMF - see Section 5) - 90 acres

g. Dam

(1) Type - Earthfill.

(2) Length of crest - 6759 feet

(3) Maximum height of dam above streambed - 105 feet ±

(4) Top width - approximately 8 feet at the northwest end of the impoundment to about 40 feet at the south end.

(5) Side Slopes -

(a) Downstream 1.5(H) to 1.0(V)

(b) Upstream slope: approximately 1.5(H) to 1.0 (V) where exposed at north side of impoundment

(6) Zoning - The embankment probably consists of a clay starter dam at the south end of the impoundment with overlying sands and gravels that are finer than 7/8-inch.

(7) Cutoff - There is no information available that pertains to the design or construction of a cutoff.

h. Spillway. There is no spillway at this dam; however, the breach at the north end of the impoundment effectively acts as a spillway. The breach is 265 feet wide at the bottom, 329 feet wide at the top and 29 feet deep. The tailings level in the breached section varies from El. 807 to El. 810 M.S.L.

i. Regulating Outlets. There are no regulating outlets at this dam. Not applicable.

j. Diversion Ditches. A diversion ditch carries water from the north end of the impoundment around the west side of the impoundment to the upper end of the pond formed downstream by Lower Dresser No. 4 Dam (I.D. 31123). This ditch is U-shaped and about 8 to 10 feet deep. This ditch was excavated in clayey soil containing rock fragments. A cross-section of the ditch at Station 29+96 is shown in Plate 5A.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design drawings or data were available.

2.2 CONSTRUCTION

Mr. A. E. Williams, the owner's representative, indicated that he did not know when the dam was constructed, but he estimated that construction may have commenced in about 1942. Dresser purchased the dam in about 1955 from J. R. Dillinger Company.

No detailed construction data were available. This dam was probably constructed by the method generally used to construct barite tailings dams in southeast Missouri. An earthfill starter dam was probably constructed across the drainage at the south end of the impoundment. Sands and gravels were then hauled in trucks from the mill and dumped on the crest to raise the dam. The sands and gravels were spread and were pushed over the upstream and downstream faces of the dam. The material pushed over the upstream side rests on the tailings. The sands and gravels placed in this manner are in a loose state and are at their natural angle of repose on the downstream face. The centerline of the dam remained approximately at the same position as the embankment was raised above the starter dam. Material on the crest was compacted by construction equipment.

On 15 August 1975, Dresser No. 4 Dam failed at the north (upstream) end of the impoundment causing the release of barite tailings and water. The details of the failure are contained in a report by J. H. Williams of the Missouri Geological Survey dated 22 September 1975 and entitled "Engineering Geologic Aspects of Barite Tailings Pond Failure, Dresser No. 4, Washington County, MO". The report is in Appendix B. The size of the pond at the time of the failure was 135 acres, with 75 acres of exposed tailings and 60 acres of clear water lakes. The height of the dam above the natural ground surface at the point of failure, where the embankment crossed a stream channel that flowed to the south, was about 50 feet. The breach that resulted from the failure was about 300 feet wide. The section that failed acted to filter the water from the barite tailings so that clear water could be discharged or recycled to the mill. Williams indicated in the 1975 report that the embankment section that failed could have been founded on natural alluvial soils and even possibly on soft barite tailings. It was postulated that weak foundation materials caused the 1975 failure of Dresser No. 4 Dam. The portion of the dam to the west of the breach was damaged subsequent to the failure and outflow of tailings and water. This damage reportedly consisted of rotational slides, which moved inward toward the pond. Extensive fractures parallel to the alignment of the dam were reported to have occurred on the crest.

2.3 OPERATION

No records of operation are known to exist.

2.4 EVALUATION

a. Availability. There are no engineering data available. The only information available to the inspection team was a verbal communication with the owner's representative pertaining to construction.

b. Adequacy. The field surveys and visual inspections presented herein are considered adequate to support the conclusions of this report. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available; the lack of this information is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions, including earthquake loads, and made a matter of record.

c. Validity. Not applicable because no design data were available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. The dam was inspected by a civil engineer and an engineering geologist from International Engineering Company, Inc. on 24 March 1979. Mr. A. E. Williams, a representative of Dresser Minerals met with the inspection team on 21 March 1979.

The impoundment contains barite tailings; however, tailings are no longer conveyed to the impoundment. The dam failed in 1975 by breaching at the north end of the impoundment. The tailings surface slopes downward toward the breach; the impoundment cannot retain water because of the breach in the dam. Photographs taken during the inspection are included in this report. The field locations of the photographs are shown in Plate 6.

b. Project Geology. Bedrock in the area is massive dolomite of late Cambrian age. It is overlain by dark red-brown residual clay that generally ranges in depth from 1 or 2 feet to 10 feet. The clay soil contains masses of barite, chert, and quartz druse. The surface of the bedrock is highly irregular and contains numerous pinnacles of chert and quartz druse.

c. Dam. The plan of the dam is shown in Plate 3. The profile and cross-sections of the dam are shown in Plates 4 and 5.

The embankment itself is practically free of vegetation. The tailings pond is vegetated with brush.

No detrimental settlement, depressions, sinkholes or animal burrows were observed in the embankment. Several cracks that parallelled the embankment alignment were noted on the crest of the northwest section (see Photo No. 4). Locally, these cracks were 2 inches wide and 2 to 3 feet deep at a minimum. No vertical displacement was observed. Vertical scarps about 2 feet high on the upstream face of the northwest portion of the dam were evident (see Photo No. 5).

Gravel is being excavated from the dam at the east side of the impoundment. The tailings surface is higher than the crest of the dam in this area as a result of the excavation activity (see Plate 5B, Dam Cross-Section at Station 59+00 and Photo No. 2).

A marshy area is located at the downstream side of the south section, and a spring at Station 16+17 is located immediately to the east of this area (see Plate 6). Flow from the spring was clear and was estimated to be about 2 gpm. The soil in the channel was clayey and soft, and some green algae was growing in the channel. Piping may have occurred because silt sediment was observed on leaves in the channel; this indicates recent deposition. A seep was observed at the maximum section (Station 11+25) at the south side of the impoundment. The estimated flow was about 1/2-gpm

and it was clear. The soil downstream of the toe of the dam at the seep was very soft to a depth of 2 to 3 feet. Some piping may also have occurred at this location.

The maximum difference in elevation from the dam crest to the tailings surface is about 30 feet. This difference occurs at the north end of the impoundment where the tailings surface is at the lowest elevation. The dam crest has been lowered typically about 6 to 8 feet below the tailings level at the east end of the impoundment where gravels are being excavated from the embankment.

d. Appurtenant Structures. There is no active spillway or outlet pipe at this dam. The 300-foot wide breach at the north end of the impoundment acts as an outlet. The soft clay tailings slope downward toward the breach and also are upstream of the breach to the north of the impoundment.

Two 12-inch diameter steel pipes are located at the northwest end of the impoundment at Stations 37+88 and 37+90. These pipes are embedded in the embankment sands and gravels. The inlet end of the pipe at Station 37+88 is buried within the embankment and is inactive. The inlet end of the pipe at Station 37+90 is bent downward about 6.3 feet below the outlet level. The pipe at the bend is about 10 feet above the tailings surface, and this pipe is inactive.

An 8-inch diameter steel pipe that emerges from the toe of the dam at the south side of the impoundment near the maximum section was located during the visual inspection. The pipe was partially plugged with soil, and the inlet end could not be found and was presumed to be buried beneath the tailings. It is not known if this pipe was intended to function as an outlet pipe.

The diversion ditch on the west and south sides of the impoundment is U-shaped and about 8 to 10 feet deep. A cross-section of the ditch is shown in Plate 5A. The ditch is in clayey soil. The flow at the time of the inspection was measured to be about 12 inches deep. The ditch discharges into the pond formed by Lower Dresser No. 4 Dam (I.D. 31123) that is located downstream.

e. Reservoir Area. The impoundment consists of soft red-brown silty clay tailings that are overgrown with brush. The tailings surface slopes downward toward the breach in the dam at the north end of the impoundment. The reservoir area is encircled by the dam; therefore, no sedimentation can occur within the impoundment. Also, drainage from the watershed is diverted around the impoundment. Since the dam was breached in August 1975, no water can be retained in the impoundment.

Ponding can occur upstream of the impoundment and to the north of the breach. A highway and a few dwellings would be subject to potential backwater flooding.

f. Downstream Channels. The upstream end of a pond is formed in the natural drainage by Lower Dresser No. 4 Dam (I.D. No. 31123) and is approximately 600 to 700 feet downstream from the dam crest. The embankment of Lower Dresser No. 4 Dam is about 1500 feet downstream. The natural drainage flows into a tributary of Mill Creek about 0.5-mile downstream of the south end of the impoundment formed by Dresser No. 4 Dam.

3.2 EVALUATION

The impoundment cannot retain water in its present state. Runoff flows north over the tailings surface and exits through the breach in the dam.

The soft soil conditions downstream of the dam at the south end of the impoundment and the steep downstream slope could adversely affect the stability of the embankment. The soils were very soft to a depth of 2 to 3 feet at the seep, which is at the maximum section.

The slope facing the impoundment at the northwest section of the dam appears to be unstable. Cracks in the dam crest and the scarps which may have resulted from previous slide activity are indications of slope instability. As long as the impoundment remains inactive and cannot retain water, the consequences of slope instability toward the impoundment would not appear to be serious.

The excavation of gravels from the dam has reduced the stability of the dam at the east section of the impoundment.

Heavy flood discharge in the diversion ditch along the west side of the impoundment could cause erosion of the toe of the embankment. Also, heavy discharges could erode the diversion ditch itself. Erosion could cause sediment to be deposited in the reservoir formed by Lower Dresser No. 4 Dam (an intermediate size dam) and could cause a decrease in its storage capacity.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no regulating structures at this dam and no regulating procedures are known to exist. This dam cannot retain water in its present state. Surface runoff would pass through the breach at the north end of the impoundment.

4.2 MAINTENANCE OF DAM

Information available to the inspection team indicates that the dam is not regularly maintained.

4.3 MAINTENANCE OF OPERATING FACILITIES

There are no operating facilities at this dam. Not applicable.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

Information available to the inspection team indicates that there is no warning system for this dam.

4.5 EVALUATION

The behavior of the dam should be monitored periodically to observe any indications of instability, such as cracks in the dam, sloughing, sudden settlement, erosion of the dam or diversion ditch, or an increase in the volume or turbidity of emerging seepage. Particular attention should be given to indications of instability of the embankment section between Stations 5+00 and 25+00 at the south end of the impoundment. A maintenance program should be initiated for the dam and diversion ditch.

SECTION 5 - HYDRAULIC AND HYDROLOGIC ANALYSES

5.1 EVALUATION OF FEATURES

a. Design Data. The significant dimensions of the dam and diversion ditch are presented in Section 1 - Project Information and in the accompanying field survey drawings, Plates 3 through 5. Hydrologic and hydraulic design information are not available.

For this evaluation, the watershed drainage area, stream lengths, and reservoir areas were obtained from the 1937 7-1/2-minute USGS Tiff, Missouri Quadrangle, which has a 20-foot contour interval. The soil group for this watershed is classified as Clarksville Gravelly Loam, equivalent to a hydrologic soil group B classification, which has a moderate rate of water transmission.

The drainage area is about 528 acres (0.825 square miles). The watershed above the tailings dam, as shown on Plate 2, can be hydrologically subdivided into two parts: the area within the circular tailings impoundment (74 acres) and the watershed upstream of the impoundment (454 acres). Land use and vegetation patterns on the upper watershed were determined from field observations and aerial photographs of the area; these patterns are divided into the following categories:

Type of Cover	Approximate Percent of Watershed
Woodlands	17
Old Mined Areas	50
Recently Mined Areas	10
Homesteads and Roads	10
Tailings (from barite mining)	13

The estimated runoff curve numbers (CN) weighted for the upper watershed are CN 54 for the antecedent moisture condition (AMC) II condition and CN 73 for the AMC III condition.

The tailings inside the circular embankment consist of recently disposed tailings from barite mining. The estimated runoff curve numbers for the tailings are AMC II, CN 80 and AMC III, CN 97.

It was assumed for these analyses that all the roads and the drainage facilities within the watershed would not substantially change the time of concentration or the quantity of the flood contribution to the impoundment. Only minor two-lane roads are within the watershed. The old and recently mined areas within the watershed are mostly barite mining sites, which consist of irregular scars on the topography. These areas were assigned lower runoff curve numbers in the overall weighting of the basin CN. The computed parameters, such as lag time, unit hydrograph, probable maximum precipitation, losses and net runoff, are in Appendix A.

The northern part (upstream side) of the impoundment has been breached, and the breach is over 300 feet wide (see Plate 4C). The tailings surface inside the impoundment slopes downward to the north through the breached section while the natural ground surface slopes downward to the south toward the impoundment forming a topographic depression. The reservoir capacity consists of the storage available in this depression. The reservoir area-capacity data are in Appendix A. The capacities were determined in the computer program by the conic method; they are the relative capacities above the minimum elevation that was entered as input, and not the total reservoir capacities at the given elevations.

The average elevation of the ground surface immediately north of the impoundment was assumed to be El. 807. One cross-section for the drainage ditch was surveyed, and this is located at about Sta. 30+00 (see Plate 5A). The ditch entrance, at about Sta. 39+00, was assumed to have the same geometry as the surveyed section. The ditch invert at the entrance was assumed to be at El. 807.

The channel bottom slope approaches the critical slope for the beginning reach of the diversion ditch. Two methods were employed to compute the discharge rating curve for the ditch:

- o Critical flows at different critical flow depths were computed using the critical flow formula.

- o Manning's equation for uniform flow, using the bottom slope of the beginning reach of the ditch (Sta. 39+00 to Sta. 30+00) as the average bottom slope ($S = 0.00822$) and a Manning's "n" of 0.035.

At a given depth, the discharge and velocity computed by the Manning's equation were slightly less than the computed critical discharge and velocity. The results computed by the Manning's equation for uniform flow were adopted as the discharge capacities for the ditch. These are shown in Appendix A as Y4 and Y5 cards in the data input and also appear in the computer printouts.

b. Experience Data. Recorded rainfall, streamflow and flood data are not available. The upstream side of the impoundment was breached in August 1975. Data and information on this failure are presented in Section 2 and Appendix B.

c. Visual Observations. Specific information on the visual observations is presented in Section 3 - Visual Inspection.

d. Overtopping Potential. Because the embankment has failed, it is not meaningful to analyze the overtopping potential of the embankment. Instead, studies were made to estimate the amount of flow and velocities that might occur in the diversion ditch under different flood conditions. High flows and discharge velocities in the ditch could lead to significant erosion of the ditch and the embankment toe, which could cause additional embankment failure.

The 100-year flood, probable maximum flood (PMF), and floods expressed as percentages of the PMF were computed and routed through the area of the depression and diversion ditch. The PMF is defined as the hypothetical flood event that would result from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible at a particular location.

The Modified Puls Method of flood routing was employed. For all routings, the water surface elevation in the depression was set at El. 807, the assumed invert elevation of the ditch. It was assumed that erosion of the ditch and of the outside toe of the embankment will not occur as flood discharges and velocities increase; therefore, the discharge rating curve was computed for a specific cross-section and entrance configuration.

The discharge capacity of the diversion ditch flowing full (2455 cfs) was estimated to be adequate to pass the outflow resulting from the PMF. The routed outflow from the PMF was calculated to equal 2275 cfs with a peak discharge velocity of 11.9 feet per second. However, significant erosion of the diversion ditch and adjacent embankment materials would occur at that discharge velocity.

Based on the Corps of Engineers Manual EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", the maximum permissible velocity for the clayey soil in the diversion ditch was estimated at about 4 feet per second. Using this as the criterion, the diversion ditch could pass the 100-year flood but could sustain some erosion. This erosion might not be significant because the peak velocitv was calculated to be slightly greater than 4 feet per second. The 100-year peak inflow was estimated to be 370 cfs. The routed peak outflow is 75 cfs at an approxmiate velocity of 4.4 feet per second and a flow depth of about 1.5 feet in the ditch. Using 4 feet per second as the permissible velocity, the diversion ditch can pass about 5 percent PMF without erosion. At 5 percent PMF, the peak outflow is about 57 cfs at a flow depth of 1.25 feet and a velocity of 4 feet per second.

Results of the analyses are reported in Appendix A and are summarized below.

Flood	Peak Inflow (cfs)	Peak Outflow (cfs)	Max WS Elev** (ft)	Ditch Flow Depth (ft)	Flow Velocity in Ditch (ft/sec)	Duration Vel. in Ditch over 4 ft/sec (hr)
10% PMF	462	126	809.3	1.9*	5.1*	8.6
25% PMF	1154	433	811.4	3.6*	7.5*	14.2
50% PMF	2308	1015	813.3	5.6*	9.6*	15.7
65% PMF	3001	1365	815.0	6.4*	10.3*	17.8
80% PMF	3694	1782	816.0	7.3*	11.1*	19.1
PMF	4617	2275	817.2	8.2*	11.9*	20.6

* These flow depths and velocities are considered to produce the effects of significant erosion.

** Water surface elevation is in the topographic depression at upstream (north) end of impoundment.

Note: Water surface elevations include the velocity heads corresponding to the velocities computed for the various flow depths for the diversion ditch section.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Conditions that may adversely affect the structural stability of the dam are discussed in Section 3.

b. Design and Construction Data. No design or construction data pertaining to the structural stability of the dam were available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and the lack of this information is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions, including earthquake loads, and made a matter of record.

c. Operating Records. No appurtenant structures requiring operation exist at this dam and no records were located.

d. Post-Construction Changes. Barite tailings have not been conveyed to the impoundment since the August 1975 failure that caused a breach in the dam. Excavation of gravels from the embankment has decreased the stability of the dam at the east side of the impoundment.

e. Seismic Stability. The dam is located in Seismic Zone 2, as defined in the Uniform Building Code. Because of the large height of the dam and the soft saturated clay foundation soil, there appears to be a potential for instability caused by ground shaking during earthquakes. Some ravelling of the gravels and crest settlement could also occur during seismic shaking because the gravels are loose and the downstream slope is at or near the natural angle of repose.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. The dam cannot retain water in its present condition because of the breach in the dam. There are several deficiencies that should be corrected. (1) The soft soil conditions at the south end of the impoundment could adversely affect the stability of the embankment. (2) The excavation of gravels from the dam has reduced the stability of the dam at the east section of the impoundment. (3) Flood discharge in the diversion ditch could cause erosion of the toe of the dam at the west side of the embankment. Also, erosion of the ditch itself could occur. The discharge capacity of the ditch was computed to be inadequate to pass 50 percent of the Probable Maximum Flood (PMF) without significant erosion of the diversion ditch and adjacent embankment materials. Because there is an intermediate size dam immediately downstream (Lower Dresser No. 4 Dam), the discharge capacity of the ditch should be adequate to pass the PMF without significant erosion of the ditch and embankment. Erosion could cause sediment to be deposited in the reservoir formed by Lower Dresser No. 4 Dam, thus causing a decrease in its storage capacity. (4) Seepage and stability analyses were not available, and they should be made a matter of record.

b. Adequacy of Information. No detailed design or construction data were available. Seepage and stability analyses comparable to the requirements of "Recommended Guidelines for Safety Inspection of Dams" were not available, and this lack of data is considered a deficiency.

Results of the hydrologic studies could be changed if larger scale topographic maps with smaller contour intervals were used. The only available topographic map is the 7.5-minute, 1:24,000 scale, 20-foot contour interval USGS quadrangle. This quadrangle pre-dates the construction of the dam, and no topographical information exists for the tailings surface within and immediately north of the impoundment. All measurements made on this map, such as drainage area, stream lengths, river slopes and reservoir area-capacity data, are insufficient in details, but the map suffices for the Phase I inspection. The use of the USGS quadrangle for the hydrologic studies results in an approximate evaluation of the diversion ditch discharge capacity.

c. Urgency. The Phase I inspection indicated apparent deficiencies in the condition of the dam. Priority should be given to initiating seepage and stability analyses.

d. Necessity for Phase II. No Phase II investigation is recommended; however, additional investigative work should be done as necessary so that seepage and stability analyses can be performed. The investigations should be undertaken by a professional engineer experienced in the design and construction of tailings dams.

7.2 REMEDIAL MEASURES

The following remedial measures are recommended:

a. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of tailings dams. Emphasis should be placed on the section of dam between Stations 5+00 and 25+00 at the south end of the impoundment because soft foundation soil conditions were encountered in portions of this section. Based on the results of the stability studies, remedial measures may become necessary. Remedial work should be done under the direction of an engineer experienced in tailings dam design and construction.

b. Erosion protection should be provided in the diversion ditch and it should be adequate to withstand the peak discharge velocity resulting from the PMF so that significant erosion of the ditch and adjacent embankment will not occur.

c. The excavation of gravels from the embankment should be stopped so that the stability of the embankment and crest elevation would not be reduced.

d. An inspection and maintenance program should be initiated. Periodic inspections should be made by qualified personnel to observe the performance of the dam and diversion ditch. Observations should include indications of instability, such as cracks in the embankment, sloughing, erosion, sudden settlement or an increase in the volume or turbidity of the seepage areas. Records should be kept of these inspections and of any corrective maintenance made to the dam and diversion ditch.

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

The hydrologic and hydraulic analyses were accomplished by using the computer program "Flood Hydrograph Package, HEC-1, Dam Safety Investigations Version, July 1978". This program was developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The criteria and methodology used are briefly discussed below:

- Probable Maximum Precipitation (PMP) - The 24-hour PMP was obtained from Hydrometeorological Report No. 33. The 6-hour and the 1-hour depth-duration distributions followed Corps of Engineers EM 1110-2-1411 criteria.

- 100-year and/or 10-year storms - The 24-hour storm amounts and distributions were supplied by Corps of Engineers, St. Louis District, Missouri.

- Unit Hydrograph - The Soil Conservation Service (SCS) curvelinear unit hydrograph method was used. Basin lag time was computed by using the SCS Curve Number Method and equation.

- Hydrologic Soil Group, Antecedent Moisture Condition (AMC) and Curve Number (CN) - The predominant hydrologic soil group for the watershed was obtained from an agricultural soil classification map prepared by the University of Missouri Agricultural Experiment Station. For the PMF and floods expressed as a percent of PMF, AMC III conditions were used. For the 100-year and/or 10-year floods, AMC II conditions were assumed. Watershed CN was estimated from field observations and from aerial photos.

- Reservoir Area-Capacity - Areas were measured from U.S.G.S. topographic maps. Reservoir elevations and corresponding surface areas were input in the computer program, which determined the reservoir capacities by the Conic Method.

- Reservoir and Spillway Flood Routing - The Modified Puls Method was used for all flood routing through spillway and dam overtopping analyses.

The following pages present the input data listing, the computer program version and its last modification date, together with pertinent computer printouts of results. Definitions of all input and output variable names are presented in the computer program "Users Manual", September 1978, and are not explained herein.

```
A1        DRESSER NO. 4 (30474)
A2        HEC-1  PHASE 1 DAM SAFETY INVESTIGATION
A3        RATIOS OF PMF ROUTED THROUGH BASIN
H     288               5                                                 2
B1      5
J       1       6       1
J1    .10     .25     .50     .65     .80     1.0
K       0 INFLOW                                1
K1 INFLOW FROM UPPER WATERSHED
M       1       2     .71                       1                         1
P       0    25.5     102     120     130
T                                                       -1     -73
W2            .72
X     -10     -.1     2.5
K       0 INFLOW                                1
K1INFLOW FROM BREACHED CIRCULAR EMBANKMENT
M       1       2     .12                       1                         1
P       0    25.5     102     120     130
T                                                       -1     -97
W2            .20
X     -10     -.1     2.5
K       2 UP+DI
K1COMBINE RUNOFF, UPPER WATERSHED AND CIRCULAR EMBANKMENT
K       1 U LAKE                        2
K1ROUTING FROM UPPER WATERSHED AND CIRCULAR EMBANKMENT
Y                               1       1
Y1      1                                             -807      -1
Y4    807   808.7   809.9   812.5   815.0   817.6   818.9   820.2   822.4   822.7
Y5      0      70     189     621    1359    2456    3160    4131    6157    6967
$A     30      33    46.7    73.9   118.2     159     193     219     239
$E    805     807     810     815     820     825     830     834     840
$$    807
$D  824.5
```

```
********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
********************************

RUN  DATE• 79/06/29.
     TIME• 14.39.14.


                        DRESSER NO. 4 (30474)
                        HEC-1  PHASE 1 DAM SAFETY INVESTIGATION
                        RATIOS OF PMF ROUTED THROUGH BASIN

                                          JOB SPECIFICATION
          NQ      NHR     NMIN    IDAY     IHR     IMIN    METRC     IPLT     IPRT    NSTAN
         288        0        5       0       0        0        0        0        2        0
                                  JOPER     NWT    LROPT   TRACE
                                      5       0        0       0

                                   MULTI-PLAN ANALYSES TO BE PERFORMED
                                        NPLAN= 1 NRTIO= 6 LRTIO= 1
            RTIOS=     .10     .25     .50     .65     .80    1.00


     **********      **********      **********      **********      **********

                                  SUB-AREA RUNOFF COMPUTATION

          INFLOW FROM UPPER WATERSHED

                      ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                     INFLOW       0       0       0       0       1       0       0       0

                                          HYDROGRAPH DATA
          IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
              1       2     .71    0.00     .71    1.00   0.000       0       1       0

                                           PRECIP DATA
                    SPFE     PMS      R6     R12     R24     R48     R72     R96
                    0.00   25.50  102.00  120.00  130.00    0.00    0.00    0.00

                                            LOSS DATA
       LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
           0    0.00    0.00    1.00    0.00    0.00    1.00   -1.00  -73.00    0.00    0.00

          CURVE NO =  -73.00  WETNESS =   -1.00  EFFECT CN =   73.00

                                        UNIT HYDROGRAPH DATA
                                     TC=  0.00     LAG=   .72

                                          RECESSION DATA
                             STRTQ=  -10.00    QRCSN=    -.10    RTIOR= 2.50

         UNIT HYDROGRAPH 45 END OF PERIOD ORDINATES, TC=    0.00 HOURS, LAG=    .72  VOL= 1.00
       16.        53.       101.       167.       252.       338.       402.       439.       449.       446.
      417.       382.       341.       289.       234.       191.       159.       133.       113.        95.
```

80.	66.	56.	48.	39.	32.	27.	23.	19.	16.
13.	11.	9.	8.	6.	6.	5.	4.	4.	3.
2.	2.	1.	1.	0.					

END-OF-PERIOD FLOW

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	6.	1.01	12.05	145	.22	.18	.04	275.
1.01	.10	2	.01	0.00	.01	6.	1.01	12.10	146	.22	.18	.04	283.
1.01	.15	3	.01	0.00	.01	5.	1.01	12.15	147	.22	.18	.04	297.
1.01	.20	4	.01	0.00	.01	5.	1.01	12.20	148	.22	.18	.03	319.
1.01	.25	5	.01	0.00	.01	4.	1.01	12.25	149	.22	.18	.03	353.
1.01	.30	6	.01	0.00	.01	4.	1.01	12.30	150	.22	.19	.03	397.
1.01	.35	7	.01	0.00	.01	4.	1.01	12.35	151	.22	.19	.03	450.
1.01	.40	8	.01	0.00	.01	3.	1.01	12.40	152	.22	.19	.03	508.
1.01	.45	9	.01	0.00	.01	3.	1.01	12.45	153	.22	.19	.03	568.
1.01	.50	10	.01	0.00	.01	3.	1.01	12.50	154	.22	.19	.03	628.
1.01	.55	11	.01	0.00	.01	3.	1.01	12.55	155	.22	.19	.03	685.
1.01	1.00	12	.01	0.00	.01	2.	1.01	13.00	156	.22	.19	.02	739.
1.01	1.05	13	.01	0.00	.01	2.	1.01	13.05	157	.26	.23	.03	788.
1.01	1.10	14	.01	0.00	.01	2.	1.01	13.10	158	.26	.23	.03	832.
1.01	1.15	15	.01	0.00	.01	2.	1.01	13.15	159	.26	.23	.03	871.
1.01	1.20	16	.01	0.00	.01	2.	1.01	13.20	160	.26	.24	.02	907.
1.01	1.25	17	.01	0.00	.01	1.	1.01	13.25	161	.26	.24	.02	943.
1.01	1.30	18	.01	0.00	.01	1.	1.01	13.30	162	.26	.24	.02	979.
1.01	1.35	19	.01	0.00	.01	1.	1.01	13.35	163	.26	.24	.02	1014.
1.01	1.40	20	.01	0.00	.01	1.	1.01	13.40	164	.26	.24	.02	1049.
1.01	1.45	21	.01	0.00	.01	1.	1.01	13.45	165	.26	.24	.02	1083.
1.01	1.50	22	.01	0.00	.01	1.	1.01	13.50	166	.26	.24	.02	1116.
1.01	1.55	23	.01	0.00	.01	1.	1.01	13.55	167	.26	.24	.02	1143.
1.01	2.00	24	.01	0.00	.01	1.	1.01	14.00	168	.26	.24	.02	1169.
1.01	2.05	25	.01	0.00	.01	1.	1.01	14.05	169	.33	.30	.02	1194.
1.01	2.10	26	.01	0.00	.01	1.	1.01	14.10	170	.33	.30	.02	1218.
1.01	2.15	27	.01	0.00	.01	1.	1.01	14.15	171	.33	.31	.02	1242.
1.01	2.20	28	.01	0.00	.01	1.	1.01	14.20	172	.33	.31	.02	1267.
1.01	2.25	29	.01	0.00	.01	0.	1.01	14.25	173	.33	.31	.02	1296.
1.01	2.30	30	.01	0.00	.01	0.	1.01	14.30	174	.33	.31	.02	1329.
1.01	2.35	31	.01	0.00	.01	0.	1.01	14.35	175	.33	.31	.02	1364.
1.01	2.40	32	.01	0.00	.01	0.	1.01	14.40	176	.33	.31	.02	1401.
1.01	2.45	33	.01	0.00	.01	0.	1.01	14.45	177	.33	.31	.02	1437.
1.01	2.50	34	.01	0.00	.01	0.	1.01	14.50	178	.33	.31	.01	1472.
1.01	2.55	35	.01	0.00	.01	0.	1.01	14.55	179	.33	.31	.01	1505.
1.01	3.00	36	.01	0.00	.01	0.	1.01	15.00	180	.33	.31	.01	1535.
1.01	3.05	37	.01	0.00	.01	0.	1.01	15.05	181	.20	.19	.01	1560.
1.01	3.10	38	.01	0.00	.01	0.	1.01	15.10	182	.40	.38	.02	1580.
1.01	3.15	39	.01	0.00	.01	0.	1.01	15.15	183	.40	.38	.02	1597.
1.01	3.20	40	.01	0.00	.01	0.	1.01	15.20	184	.59	.57	.02	1616.
1.01	3.25	41	.01	0.00	.01	0.	1.01	15.25	185	.69	.67	.02	1643.
1.01	3.30	42	.01	0.00	.01	0.	1.01	15.30	186	1.68	1.63	.05	1702.
1.01	3.35	43	.01	0.00	.01	0.	1.01	15.35	187	2.77	2.70	.07	1838.
1.01	3.40	44	.01	0.00	.01	0.	1.01	15.40	188	1.09	1.06	.02	2080.
1.01	3.45	45	.01	0.00	.01	0.	1.01	15.45	189	.69	.68	.01	2361.
1.01	3.50	46	.01	0.00	.01	0.	1.01	15.50	190	.59	.58	.01	2741.
1.01	3.55	47	.01	0.00	.01	0.	1.01	15.55	191	.40	.39	.01	3178.
1.01	4.00	48	.01	0.00	.01	0.	1.01	16.00	192	.40	.39	.01	3595.
1.01	4.05	49	.01	0.00	.01	0.	1.01	16.05	193	.30	.30	.01	3924.
1.01	4.10	50	.01	0.00	.01	0.	1.01	16.10	194	.30	.30	.01	4153.
1.01	4.15	51	.01	0.00	.01	0.	1.01	16.15	195	.30	.30	.00	4222.
1.01	4.20	52	.01	0.00	.01	0.	1.01	16.20	196	.30	.30	.00	4203.
1.01	4.25	53	.01	.00	.01	0.	1.01	16.25	197	.30	.30	.00	4079.

1.01	4.30	54	.01	.00	.01	0.	1.01	16.30	198	.30	.30	.00	3891.
1.01	4.35	55	.01	.00	.01	0.	1.01	16.35	199	.30	.30	.00	3653.
1.01	4.40	56	.01	.00	.01	0.	1.01	16.40	200	.30	.30	.00	3375.
1.01	4.45	57	.01	.00	.01	0.	1.01	16.45	201	.30	.30	.00	3097.
1.01	4.50	58	.01	.00	.01	0.	1.01	16.50	202	.30	.30	.00	2857.
1.01	4.55	59	.01	.00	.01	0.	1.01	16.55	203	.30	.30	.00	2657.
1.01	5.00	60	.01	.00	.01	0.	1.01	17.00	204	.30	.30	.00	2491.
1.01	5.05	61	.01	.00	.01	1.	1.01	17.05	205	.24	.24	.00	2354.
1.01	5.10	62	.01	.00	.01	1.	1.01	17.10	206	.24	.24	.00	2236.
1.01	5.15	63	.01	.00	.01	1.	1.01	17.15	207	.24	.24	.00	2132.
1.01	5.20	64	.01	.00	.01	2.	1.01	17.20	208	.24	.24	.00	2038.
1.01	5.25	65	.01	.00	.01	2.	1.01	17.25	209	.24	.24	.00	1956.
1.01	5.30	66	.01	.00	.01	2.	1.01	17.30	210	.24	.24	.00	1877.
1.01	5.35	67	.01	.00	.01	3.	1.01	17.35	211	.24	.24	.00	1804.
1.01	5.40	68	.01	.00	.01	3.	1.01	17.40	212	.24	.24	.00	1736.
1.01	5.45	69	.01	.00	.01	4.	1.01	17.45	213	.24	.24	.00	1673.
1.01	5.50	70	.01	.00	.01	4.	1.01	17.50	214	.24	.24	.00	1617.
1.01	5.55	71	.01	.00	.01	5.	1.01	17.55	215	.24	.24	.00	1567.
1.01	6.00	72	.01	.00	.01	5.	1.01	18.00	216	.24	.24	.00	1523.
1.01	6.05	73	.06	.01	.05	6.	1.01	18.05	217	.02	.02	.00	1482.
1.01	6.10	74	.06	.01	.05	7.	1.01	18.10	218	.02	.02	.00	1439.
1.01	6.15	75	.06	.01	.05	8.	1.01	18.15	219	.02	.02	.00	1391.
1.01	6.20	76	.06	.01	.05	10.	1.01	18.20	220	.02	.02	.00	1333.
1.01	6.25	77	.06	.02	.05	13.	1.01	18.25	221	.02	.02	.00	1261.
1.01	6.30	78	.06	.02	.05	17.	1.01	18.30	222	.02	.02	.00	1174.
1.01	6.35	79	.06	.02	.05	22.	1.01	18.35	223	.02	.02	.0	1076.
1.01	6.40	80	.06	.02	.04	27.	1.01	18.40	224	.02	.02	.00	971.
1.01	6.45	81	.06	.02	.04	34.	1.01	18.45	225	.02	.02	.00	866.
1.01	6.50	82	.06	.02	.04	41.	1.01	18.50	226	.02	.02	.00	762.
1.01	6.55	83	.06	.02	.04	48.	1.01	18.55	227	.02	.02	.00	666.
1.01	7.00	84	.06	.02	.04	56.	1.01	19.00	228	.02	.02	.00	578.
1.01	7.05	85	.06	.03	.04	64.	1.01	19.05	229	.02	.02	.00	499.
1.01	7.10	86	.06	.03	.04	71.	1.01	19.10	230	.02	.02	.00	432.
1.01	7.15	87	.06	.03	.04	79.	1.01	19.15	231	.02	.02	.00	392.
1.01	7.20	88	.06	.03	.04	86.	1.01	19.20	232	.02	.02	.00	358.
1.01	7.25	89	.06	.03	.03	93.	1.01	19.25	233	.02	.02	.00	320.
1.01	7.30	90	.06	.03	.03	100.	1.01	19.30	234	.02	.02	.00	298.
1.01	7.35	91	.06	.03	.03	107.	1.01	19.35	235	.02	.02	.00	272.
1.01	7.40	92	.06	.03	.03	113.	1.01	19.40	236	.02	.02	.00	248.
1.01	7.45	93	.06	.03	.03	119.	1.01	19.45	237	.02	.02	.00	226.
1.01	7.50	94	.06	.03	.03	125.	1.01	19.50	238	.02	.02	.00	206.
1.01	7.55	95	.06	.03	.03	131.	1.01	19.55	239	.02	.02	.00	189.
1.01	8.00	96	.06	.03	.03	137.	1.01	20.00	240	.02	.02	.00	172.
1.01	8.05	97	.06	.04	.03	143.	1.01	20.05	241	.02	.02	.00	158.
1.01	8.10	98	.06	.04	.03	148.	1.01	20.10	242	.02	.02	.00	151.
1.01	8.15	99	.06	.04	.03	153.	1.01	20.15	243	.02	.02	.00	145.
1.01	8.20	100	.06	.04	.03	158.	1.01	20.20	244	.02	.02	.00	140.
1.01	8.25	101	.06	.04	.03	163.	1.01	20.25	245	.02	.02	.00	135.
1.01	8.30	102	.06	.04	.03	168.	1.01	20.30	246	.02	.02	.00	132.
1.01	8.35	103	.06	.04	.02	172.	1.01	20.35	247	.02	.02	.00	129.
1.01	8.40	104	.06	.04	.02	176.	1.01	20.40	248	.02	.02	.00	126.
1.01	8.45	105	.06	.04	.02	181.	1.01	20.45	249	.02	.02	.00	124.
1.01	8.50	106	.06	.04	.02	185.	1.01	20.50	250	.02	.02	.00	123.
1.01	8.55	107	.06	.04	.02	188.	1.01	20.55	251	.02	.02	.00	121.
1.01	9.00	108	.06	.04	.02	192.	1.01	21.00	252	.02	.02	.00	120.
1.01	9.05	109	.06	.04	.02	196.	1.01	21.05	253	.02	.02	.00	119.
1.01	9.10	110	.06	.04	.02	199.	1.01	21.10	254	.02	.02	.00	118.
1.01	9.15	111	.06	.04	.02	203.	1.01	21.15	255	.02	.02	.00	118.
1.01	9.20	112	.06	.04	.02	206.	1.01	21.20	256	.02	.02	.00	117.
1.01	9.25	113	.06	.04	.02	209.	1.01	21.25	257	.02	.02	.00	116.

1.01	9.30	114	.06	.04	.02	212.	1.01	21.30	258	.02	.02	.00	116.
1.01	9.35	115	.06	.04	.02	215.	1.01	21.35	259	.02	.02	.00	116.
1.01	9.40	116	.06	.04	.02	218.	1.01	21.40	260	.02	.02	.00	116.
1.01	9.45	117	.06	.04	.02	221.	1.01	21.45	261	.02	.02	.00	115.
1.01	9.50	118	.06	.05	.02	224.	1.01	21.50	262	.02	.02	.00	115.
1.01	9.55	119	.06	.05	.02	226.	1.01	21.55	263	.02	.02	.00	115.
1.01	10.00	120	.06	.05	.02	229.	1.01	22.00	264	.02	.02	.00	115.
1.01	10.05	121	.06	.05	.02	231.	1.01	22.05	265	.02	.02	.00	116.
1.01	10.10	122	.06	.05	.02	234.	1.01	22.10	266	.02	.02	.00	116.
1.01	10.15	123	.06	.05	.02	236.	1.01	22.15	267	.02	.02	.00	116.
1.01	10.20	124	.06	.05	.02	238.	1.01	22.20	268	.02	.02	.00	116.
1.01	10.25	125	.06	.05	.02	240.	1.01	22.25	269	.02	.02	.00	116.
1.01	10.30	126	.06	.05	.02	242.	1.01	22.30	270	.02	.02	.00	116.
1.01	10.35	127	.06	.05	.02	244.	1.01	22.35	271	.02	.02	.00	116.
1.01	10.40	128	.06	.05	.02	246.	1.01	22.40	272	.02	.02	.00	116.
1.01	10.45	129	.06	.05	.02	248.	1.01	22.45	273	.02	.02	.00	116.
1.01	10.50	130	.06	.05	.01	250.	1.01	22.50	274	.02	.02	.00	116.
1.01	10.55	131	.06	.05	.01	252.	1.01	22.55	275	.02	.02	.00	116.
1.01	11.00	132	.06	.05	.01	254.	1.01	23.00	276	.02	.02	.00	116.
1.01	11.05	133	.06	.05	.01	256.	1.01	23.05	277	.02	.02	.00	116.
1.01	11.10	134	.06	.05	.01	257.	1.01	23.10	278	.02	.02	.00	116.
1.01	11.15	135	.06	.05	.01	259.	1.01	23.15	279	.02	.02	.00	116.
1.01	11.20	136	.06	.05	.01	260.	1.01	23.20	280	.02	.02	.00	116.
1.01	11.25	137	.06	.05	.01	262.	1.01	23.25	281	.02	.02	.00	116.
1.01	11.30	138	.06	.05	.01	264.	1.01	23.30	282	.02	.02	.00	116.
1.01	11.35	139	.06	.05	.01	265.	1.01	23.35	283	.02	.02	.00	116.
1.01	11.40	140	.06	.05	.01	266.	1.01	23.40	284	.02	.02	.00	116.
1.01	11.45	141	.06	.05	.01	268.	1.01	23.45	285	.02	.02	.00	116.
1.01	11.50	142	.06	.05	.01	269.	1.01	23.50	286	.02	.02	.00	116.
1.01	11.55	143	.06	.05	.01	271.	1.01	23.55	287	.02	.02	.00	116.
1.01	12.00	144	.06	.05	.01	272.	1.02	0.00	288	.02	.02	.00	116.

SUM 33.15 29.09 4.06 158905.
(842.)(739.)(103.)(4499.69)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4222.	1832.	552.	552.	158836.
CMS	120.	52.	16.	16.	4498.
INCHES		24.00	28.90	28.90	28.90
MM		609.57	734.15	734.15	734.15
AC-FT		908.	1094.	1094.	1094.
THOUS CU M		1120.	1349.	1349.	1349.

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW FROM BREACHED CIRCULAR EMBANKMENT

ISTAQ ICOMP IECON ITAPE JPLT JPRT INAME ISTAGE IAUTO

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                 INFLOW       0       0       0       0       1       0       0       0

                                   HYDROGRAPH DATA
        IHYDG     IUHG    TAREA     SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LOCAL
            1        2      .12     0.00      .12     1.00    0.000        0        1        0

                                     PRECIP DATA
                  SPFE      PMS       R6      R12      R24      R48      R72      R96
                  0.00    25.50   102.00   120.00   130.00     0.00     0.00     0.00

                                      LOSS DATA
   LROPT    STRKR    DLTKR    RTIOL    ERAIN    STRKS    RTIOK    STRTL    CNSTL    ALSMX    RTIMP
       0     0.00     0.00     1.00     0.00     0.00     1.00    -1.00   -97.00     0.00     0.00

        CURVE NO =  -97.00  WETNESS =   -1.00  EFFECT CN =   97.00

                                UNIT HYDROGRAPH DATA
                              TC=  0.00     LAG=    .20

                                    RECESSION DATA
                        STRTQ=  -10.00    QRCSN=     -.10     RTIOR= 2.50

       UNIT HYDROGRAPH 14 END OF PERIOD ORDINATES, TC=     0.00 HOURS, LAG=     .20  VOL= 1.00
     58.      193.      239.      191.      106.       61.       35.       20.       11.        6.
      4.        2.        1.        0.

     0                                          END-OF-PERIOD FLOW
MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS    COMP.Q      MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS    COMP Q

 1.01    .05       1    .01   0.00    .01        1.       1.01  12.05     145    .22    .22    .00       68.
 1.01    .10       2    .01   0.00    .01        1.       1.01  12.10     146    .22    .22    .00       97.
 1.01    .15       3    .01   0.00    .01        1.       1.01  12.15     147    .22    .22    .00      134.
 1.01    .20       4    .01   0.00    .01        1.       1.01  12.20     148    .22    .22    .00      163.
 1.01    .25       5    .01    .00    .01        1.       1.01  12.25     149    .22    .22    .00      179.
 1.01    .30       6    .01    .00    .01        1.       1.01  12.30     150    .22    .22    .00      189.
 1.01    .35       7    .01    .00    .01        1.       1.01  12.35     151    .22    .22    .00      194.
 1.01    .40       8    .01    .00    .01        2.       1.01  12.40     152    .22    .22    .00      197.
 1.01    .45       9    .01    .00    .01        2.       1.01  12.45     153    .22    .22    .00      199.
 1.01    .50      10    .01    .00    .01        3.       1.01  12.50     154    .22    .22    .00      200.
 1.01    .55      11    .01    .01    .01        4.       1.01  12.55     155    .22    .22    .00      200.
 1.01   1.00      12    .01    .01    .01        4.       1.01  13.00     156    .22    .22    .00      201.
 1.01   1.05      13    .01    .01    .01        5.       1.01  13.05     157    .26    .26    .00      203.
 1.01   1.10      14    .01    .01    .01        6.       1.01  13.10     158    .26    .26    .00      212.
 1.01   1.15      15    .01    .01    .01        6.       1.01  13.15     159    .26    .26    .00      222.
 1.01   1.20      16    .01    .01    .01        6.       1.01  13.20     160    .26    .25    .00      231.
 1.01   1.25      17    .01    .01    .01        7.       1.01  13.25     161    .26    .26    .00      235.
 1.01   1.30      18    .01    .01    .01        7.       1.01  13.30     162    .26    .26    .00      236.
 1.01   1.35      19    .01    .01    .01        8.       1.01  13.35     163    .26    .26    .00      239.
 1.01   1.40      20    .01    .01    .00        8.       1.01  13.40     164    .26    .26    .00      240.
 1.01   1.45      21    .01    .01    .00        8.       1.01  13.45     165    .26    .26    .00      241.
 1.01   1.50      22    .01    .01    .00        8.       1.01  13.50     166    .26    .26    .00      241.
 1.01   1.55      23    .01    .01    .00        9.       1.01  13.55     167    .26    .26    .00      241.
 1.01   2.00      24    .01    .01    .00        9.       1.01  14.00     168    .26    .26    .00      241.
 1.01   2.05      25    .01    .01    .00        9.       1.01  14.05     169    .33    .32    .00      245.
 1.01   2.10      26    .01    .01    .00        9.       1.01  14.10     170    .33    .32    .00      258.
 1.01   2.15      27    .01    .01    .00       10.       1.01  14.15     171    .33    .32    .00      273.
 1.01   2.20      28    .01    .01    .00       10.       1.01  14.20     172    .33    .32    .00      286.
 1.01   2.25      29    .01    .01    .00       10.       1.01  14.25     173    .33    .32    .00      293.
 1.01   2.30      30    .01    .01    .00       10.       1.01  14.30     174    .33    .32    .00      297.
 1.01   2.35      31    .01    .01    .00       10.       1.01  14.35     175    .33    .32    .00      299.
```

1.01	2.40	32	.01	.01	.00	10.	1.01	14.40	176	.33	.32	.00	300.
1.01	2.45	33	.01	.01	.00	10.	1.01	14.45	177	.33	.32	.00	301.
1.01	2.50	34	.01	.01	.00	10.	1.01	14.50	178	.33	.32	.00	301.
1.01	2.55	35	.01	.01	.00	11.	1.01	14.55	179	.33	.32	.00	302.
1.01	3.00	36	.01	.01	.00	11.	1.01	15.00	180	.33	.32	.00	302.
1.01	3.05	37	.01	.01	.00	11.	1.01	15.05	181	.20	.20	.00	244.
1.01	3.10	38	.01	.01	.00	11.	1.01	15.10	182	.40	.40	.00	281.
1.01	3.15	39	.01	.01	.00	11.	1.01	15.15	183	.40	.40	.00	289.
1.01	3.20	40	.01	.01	.00	11.	1.01	15.20	184	.59	.59	.00	323.
1.01	3.25	41	.01	.01	.00	11.	1.01	15.25	185	.69	.69	.00	392.
1.01	3.30	42	.01	.01	.00	11.	1.01	15.30	186	1.68	1.68	.00	529.
1.01	3.35	43	.01	.01	.00	11.	1.01	15.35	187	2.77	2.77	.00	852.
1.01	3.40	44	.01	.01	.00	11.	1.01	15.40	188	1.09	1.09	.00	1244.
1.01	3.45	45	.01	.01	.00	11.	1.01	15.45	189	.69	.69	.00	1371.
1.01	3.50	46	.01	.01	.00	11.	1.01	15.50	190	.59	.59	.00	1214.
1.01	3.55	47	.01	.01	.00	11.	1.01	15.55	191	.40	.40	.00	952.
1.01	4.00	48	.01	.01	.00	12.	1.01	16.00	192	.40	.40	.00	742.
1.01	4.05	49	.01	.01	.00	12.	1.01	16.05	193	.30	.30	.00	565.
1.01	4.10	50	.01	.01	.00	12.	1.01	16.10	194	.30	.30	.00	472.
1.01	4.15	51	.01	.01	.00	12.	1.01	16.15	195	.30	.30	.00	395.
1.01	4.20	52	.01	.01	.00	12.	1.01	16.20	196	.30	.30	.00	346.
1.01	4.25	53	.01	.01	.00	12.	1.01	16.25	197	.30	.30	.00	319.
1.01	4.30	54	.01	.01	.00	12.	1.01	16.30	198	.30	.30	.00	305.
1.01	4.35	55	.01	.01	.00	12.	1.01	16.35	199	.30	.30	.00	293.
1.01	4.40	56	.01	.01	.00	12.	1.01	16.40	200	.30	.30	.00	287.
1.01	4.45	57	.01	.01	.00	12.	1.01	16.45	201	.30	.30	.00	284.
1.01	4.50	58	.01	.01	.00	12.	1.01	16.50	202	.30	.30	.00	283.
1.01	4.55	59	.01	.01	.00	12.	1.01	16.55	203	.30	.30	.00	282.
1.01	5.00	60	.01	.01	.00	12.	1.01	17.00	204	.30	.30	.00	282.
1.01	5.05	61	.01	.01	.00	12.	1.01	17.05	205	.24	.24	.00	278.
1.01	5.10	62	.01	.01	.00	12.	1.01	17.10	206	.24	.24	.00	265.
1.01	5.15	63	.01	.01	.00	12.	1.01	17.15	207	.24	.24	.00	250.
1.01	5.20	64	.01	.01	.00	12.	1.01	17.20	208	.24	.24	.00	238.
1.01	5.25	65	.01	.01	.00	12.	1.01	17.25	209	.24	.24	.00	231.
1.01	5.30	66	.01	.01	.00	12.	1.01	17.30	210	.24	.24	.00	227.
1.01	5.35	67	.01	.01	.00	12.	1.01	17.35	211	.24	.24	.00	224.
1.01	5.40	68	.01	.01	.00	12.	1.01	17.40	212	.24	.24	.00	223.
1.01	5.45	69	.01	.01	.00	12.	1.01	17.45	213	.24	.24	.00	222.
1.01	5.50	70	.01	.01	.00	12.	1.01	17.50	214	.24	.24	.00	222.
1.01	5.55	71	.01	.01	.00	12.	1.01	17.55	215	.24	.24	.00	222.
1.01	6.00	72	.01	.01	.00	12.	1.01	18.00	216	.24	.24	.00	222.
1.01	6.05	73	.06	.06	.00	15.	1.01	18.05	217	.02	.02	.00	209.
1.01	6.10	74	.06	.06	.00	24.	1.01	18.10	218	.02	.02	.00	167.
1.01	6.15	75	.06	.06	.00	35.	1.01	18.15	219	.02	.02	.00	132.
1.01	6.20	76	.06	.06	.00	45.	1.01	18.20	220	.02	.02	.00	120.
1.01	6.25	77	.06	.06	.00	50.	1.01	18.25	221	.02	.02	.00	110.
1.01	6.30	78	.06	.06	.00	53.	1.01	18.30	222	.02	.02	.00	100.
1.01	6.35	79	.06	.06	.00	55.	1.01	18.35	223	.02	.02	.00	91.
1.01	6.40	80	.06	.06	.00	56.	1.01	18.40	224	.02	.02	.00	83.
1.01	6.45	81	.06	.06	.00	56.	1.01	18.45	225	.02	.02	.00	76.
1.01	6.50	82	.06	.06	.00	57.	1.01	18.50	226	.02	.02	.00	69.
1.01	6.55	83	.06	.06	.00	57.	1.01	18.55	227	.02	.02	.00	63.
1.01	7.00	84	.06	.06	.00	57.	1.01	19.00	228	.02	.02	.00	58.
1.01	7.05	85	.06	.06	.00	58.	1.01	19.05	229	.02	.02	.00	53.
1.01	7.10	86	.06	.06	.00	58.	1.01	19.10	230	.02	.02	.00	48.
1.01	7.15	87	.06	.06	.00	58.	1.01	19.15	231	.02	.02	.00	44.
1.01	7.20	88	.06	.06	.00	58.	1.01	19.20	232	.02	.02	.00	40.
1.01	7.25	89	.06	.06	.00	58.	1.01	19.25	233	.02	.02	.00	37.
1.01	7.30	90	.06	.06	.00	58.	1.01	19.30	234	.02	.02	.00	33.
1.01	7.35	91	.06	.06	.00	58.	1.01	19.35	235	.02	.02	.00	30.

1.01	7.40	92	.06	.06	.00	58.	1.01	19.40	236	.02	.02	.00	28.
1.01	7.45	93	.06	.06	.00	58.	1.01	19.45	237	.02	.02	.00	25.
1.01	7.50	94	.06	.06	.00	58.	1.01	19.50	238	.02	.02	.00	23.
1.01	7.55	95	.06	.06	.00	58.	1.01	19.55	239	.02	.02	.00	21.
1.01	8.00	96	.06	.06	.00	58.	1.01	20.00	240	.02	.02	.00	20.
1.01	8.05	97	.06	.06	.00	58.	1.01	20.05	241	.02	.02	.00	20.
1.01	8.10	98	.06	.06	.00	58.	1.01	20.10	242	.02	.02	.00	20.
1.01	8.15	99	.06	.06	.00	58.	1.01	20.15	243	.02	.02	.00	20.
1.01	8.20	100	.06	.06	.00	59.	1.01	20.20	244	.02	.02	.00	20.
1.01	8.25	101	.06	.06	.00	59.	1.01	20.25	245	.02	.02	.00	20.
1.01	8.30	102	.06	.06	.00	59.	1.01	20.30	246	.02	.02	.00	20.
1.01	8.35	103	.06	.06	.00	59.	1.01	20.35	247	.02	.02	.00	20.
1.01	8.40	104	.06	.06	.00	59.	1.01	20.40	248	.02	.02	.00	20.
1.01	8.45	105	.06	.06	.00	59.	1.01	20.45	249	.02	.02	.00	20.
1.01	8.50	106	.06	.06	.00	59.	1.01	20.50	250	.02	.02	.00	20.
1.01	8.55	107	.06	.06	.00	59.	1.01	20.55	251	.02	.02	.00	20.
1.01	9.00	108	.06	.06	.00	59.	1.01	21.00	252	.02	.02	.00	20.
1.01	9.05	109	.06	.06	.00	59.	1.01	21.05	253	.02	.02	.00	20.
1.01	9.10	110	.06	.06	.00	59.	1.01	21.10	254	.02	.02	.00	20.
1.01	9.15	111	.06	.06	.00	59.	1.01	21.15	255	.02	.02	.00	20.
1.01	9.20	112	.06	.06	.00	59.	1.01	21.20	256	.02	.02	.00	20.
1.01	9.25	113	.06	.06	.00	59.	1.01	21.25	257	.02	.02	.00	20.
1.01	9.30	114	.06	.06	.00	59.	1.01	21.30	258	.02	.02	.00	20.
1.01	9.35	115	.06	.06	.00	59.	1.01	21.35	259	.02	.02	.00	20.
1.01	9.40	116	.06	.06	.00	59.	1.01	21.40	260	.02	.02	.00	20.
1.01	9.45	117	.06	.06	.00	59.	1.01	21.45	261	.02	.02	.00	20.
1.01	9.50	118	.06	.06	.00	59.	1.01	21.50	262	.02	.02	.00	20.
1.01	9.55	119	.06	.06	.00	59.	1.01	21.55	263	.02	.02	.00	20.
1.01	10.00	120	.06	.06	.00	59.	1.01	22.00	264	.02	.02	.00	20.
1.01	10.05	121	.06	.06	.00	59.	1.01	22.05	265	.02	.02	.00	20.
1.01	10.10	122	.06	.06	.00	59.	1.01	22.10	266	.02	.02	.00	20.
1.01	10.15	123	.06	.06	.00	59.	1.01	22.15	267	.02	.02	.00	20.
1.01	10.20	124	.06	.06	.00	59.	1.01	22.20	268	.02	.02	.00	20.
1.01	10.25	125	.06	.06	.00	59.	1.01	22.25	269	.02	.02	.00	20.
1.01	10.30	126	.06	.06	.00	59.	1.01	22.30	270	.02	.02	.00	20.
1.01	10.35	127	.06	.06	.00	59.	1.01	22.35	271	.02	.02	.00	20.
1.01	10.40	128	.06	.06	.00	59.	1.01	22.40	272	.02	.02	.00	20.
1.01	10.45	129	.06	.06	.00	59.	1.01	22.45	273	.02	.02	.00	20.
1.01	10.50	130	.06	.06	.00	59.	1.01	22.50	274	.02	.02	.00	20.
1.01	10.55	131	.06	.06	.00	59.	1.01	22.55	275	.02	.02	.00	20.
1.01	11.00	132	.06	.06	.00	59.	1.01	23.00	276	.02	.02	.00	20.
1.01	11.05	133	.06	.06	.00	59.	1.01	23.05	277	.02	.02	.00	20.
1.01	11.10	134	.06	.06	.00	59.	1.01	23.10	278	.02	.02	.00	20.
1.01	11.15	135	.06	.06	.00	59.	1.01	23.15	279	.02	.02	.00	20.
1.01	11.20	136	.06	.06	.00	59.	1.01	23.20	280	.02	.02	.00	20.
1.01	11.25	137	.06	.06	.00	59.	1.01	23.25	281	.02	.02	.00	20.
1.01	11.30	138	.06	.06	.00	59.	1.01	23.30	282	.02	.02	.00	20.
1.01	11.35	139	.06	.06	.00	59.	1.01	23.35	283	.02	.02	.00	20.
1.01	11.40	140	.06	.06	.00	59.	1.01	23.40	284	.02	.02	.00	20.
1.01	11.45	141	.06	.06	.00	59.	1.01	23.45	285	.02	.02	.00	20.
1.01	11.50	142	.06	.06	.00	59.	1.01	23.50	286	.02	.02	.00	20.
1.01	11.55	143	.06	.06	.00	59.	1.01	23.55	287	.02	.02	.00	20.
1.01	12.00	144	.06	.06	.00	59.	1.02	0.00	288	.02	.02	.00	20.
									SUM	33.15	32.78	.37	31075.
										(842.)(	833.)(	9.)(	879.95)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1371.	332.	108.	108.	31050.
CMS	39.	9.	3.	3.	879.

INCHES	25.78	33.43	33.43		33.43
MM	653.83	849.12	849.12		849.12
AC-FT	165.	214.	214.		214.
THOUS CU M	203.	264.	264.		264.

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COMBINE HYDROGRAPHS

COMBINE RUNOFF, UPPER WATERSHED AND CIRCULAR EMBANKMENT

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
UP+DI	2	0	0	0	0	0	0	0

SUM OF 2 HYDROGRAPHS AT UP+DI PLAN 1 RTIO 6

8.	7.	7.	6.	5.	5.	5.	5.	5.	6.
6.	7.	7.	7.	8.	8.	8.	9.	9.	9.
9.	9.	10.	10.	10.	10.	10.	10.	10.	10.
11.	11.	11.	11.	11.	11.	11.	11.	11.	11.
11.	11.	11.	11.	11.	12.	12.	12.	12.	12.
12.	12.	12.	12.	12.	12.	12.	12.	12.	12.
13.	13.	13.	14.	14.	14.	15.	15.	16.	16.
17.	17.	21.	31.	43.	54.	65.	70.	76.	83.
90.	98.	106.	113.	121.	129.	137.	144.	151.	158.
165.	171.	178.	184.	190.	196.	201.	206.	212.	217.
221.	226.	231.	235.	239.	243.	247.	251.	255.	258.
261.	265.	268.	271.	274.	277.	280.	282.	285.	288.
290.	292.	295.	297.	299.	301.	303.	305.	307.	309.
311.	313.	315.	316.	318.	319.	321.	323.	324.	325.
327.	328.	330.	331.	343.	380.	431.	482.	532.	586.
640.	705.	767.	828.	886.	939.	991.	1043.	1095.	1150.
1178.	1217.	1254.	1290.	1324.	1355.	1384.	1411.	1439.	1476.
1515.	1553.	1589.	1625.	1665.	1701.	1738.	1773.	1806.	1837.
1854.	1861.	1866.	1939.	2034.	2231.	2690.	3304.	3731.	3955.
4130.	4337.	4509.	4605.	4617.	4549.	4397.	4193.	3946.	3662.
3581.	3140.	2939.	2772.	2632.	2501.	2382.	2276.	2186.	2104.
2028.	1959.	1896.	1839.	1789.	1745.	1691.	1606.	1523.	1454.
1371.	1274.	1167.	1055.	942.	832.	729.	630.	552.	480.
436.	398.	363.	331.	302.	276.	252.	230.	209.	192.
178.	170.	164.	159.	155.	152.	149.	146.	144.	142.
141.	140.	139.	138.	137.	137.	136.	136.	135.	135.
135.	135.	135.	135.	135.	135.	135.	135.	135.	135.
135.	135.	135.	135.	135.	135.	135.	135.	135.	135.
135.	135.	135.	135.	135.	135.	135.	135.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4617.	2155.	659.	659.	189886.
CMS	131.	61.	19.	19.	5377.
INCHES		24.15	29.56	29.56	29.56
MM		613.35	750.77	750.77	750.77
AC-FT		1068.	1308.	1308.	1308.
THOUS CU M		1318.	1613.	1613.	1613.

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HYDROGRAPH ROUTING

ROUTING FROM UPPER WATERSHED AND CIRCULAR EMBANKMENT

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
U LAKE	1	0	0	2	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.0	0.000	0.00	1	1	0	0		0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-807.	-1

STAGE	807.00	808.70	809.90	812.50	815.00	817.60	818.90	820.20	822.40	822.70
FLOW	0.00	70.00	189.00	621.00	1359.00	2456.00	3160.00	4131.00	6157.00	6967.00

SURFACE AREA=	30.	33.	47.	74.	118.	159.	193.	219.	239.
CAPACITY=	0.	63.	182.	481.	957.	1647.	2526.	3349.	4723.
ELEVATION=	805.	807.	810.	815.	820.	825.	830.	834.	840.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
807.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
828.5	0.0	0.0	0.

STATION U LAKE, PLAN 1, RATIO 6

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	4.	4.	4.	4.	4.	4.	4.
4.	4.	4.	4.	4.	4.	5.	5.	5.	5.
5.	5.	5.	5.	6.	6.	6.	7.	7.	8.
9.	9.	10.	11.	12.	13.	14.	15.	16.	17.
18.	19.	21.	22.	23.	25.	26.	27.	29.	30.
32.	34.	35.	36.	38.	39.	41.	42.	44.	46.
47.	49.	50.	52.	54.	55.	57.	58.	60.	62.
63.	65.	66.	68.	70.	73.	77.	81.	84.	88.
92.	95.	99.	102.	106.	109.	113.	116.	119.	122.
126.	129.	132.	135.	138.	142.	146.	150.	156.	162.
169.	176.	184.	196.	212.	229.	247.	265.	283.	302.
322.	341.	361.	381.	401.	421.	441.	461.	481.	501.
521.	541.	562.	582.	603.	625.	662.	698.	735.	765.
803.	836.	868.	901.	934.	971.	1015.	1074.	1145.	1222.
1301.	1390.	1504.	1616.	1723.	1823.	1914.	1994.	2062.	2118.
2165.	2196.	2225.	2244.	2259.	2268.	2274.	2275.	2274.	2270.
2264.	2255.	2245.	2233.	2220.	2206.	2190.	2173.	2154.	2132.
2109.	2084.	2056.	2025.	1991.	1954.	1915.	1873.	1829.	1784.
1737.	1691.	1644.	1597.	1550.	1503.	1457.	1411.	1365.	1332.
1300.	1269.	1238.	1208.	1178.	1149.	1120.	1092.	1064.	1037.
1010.	984.	959.	934.	909.	885.	862.	839.	817.	796.
775.	754.	734.	715.	696.	677.	659.	642.	625.	614.
605.	596.	587.	578.	570.	561.	553.	544.	536.	528.
520.	513.	505.	498.	491.	483.	476.	469.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2275.	1675.	559.	559.	160971.
CMS	64.	47.	16.	16.	4558.
INCHES		19.77	25.06	25.06	25.06
MM		476.74	636.45	636.45	636.45
AC-FT		830.	1109.	1109.	1109.
THOUS CU M		1024.	1367.	1367.	1367.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .10	RATIO 2 .25	RATIO 3 .50	RATIO 4 .65	RATIO 5 .80	RATIO 6 1.00
				RATIOS APPLIED TO FLOWS					
HYDROGRAPH AT	INFLOW	.71	1	422.	1055.	2111.	2744.	3378.	4222.
	(	1.84)	(	11.96)(	29.89)(	59.78)(	77.71)(	95.64)(	119.55)(
HYDROGRAPH AT	INFLOW	.12	1	137.	343.	685.	891.	1096.	1371.
	(	.31)	(	3.88)(	9.70)(	19.41)(	25.23)(	31.05)(	38.81)(
2 COMBINED	OP+PI	.83	1	462.	1154.	2308.	3001.	3694.	4617.
	(	2.15)	(	13.07)(	32.68)(	65.37)(	84.98)(	104.59)(	130.74)(
ROUTED TO	U LAKE	.83	1	126.	433.	1015.	1365.	1782.	2275.
	(	2.15)	(	3.57)(	12.26)(	28.75)(	38.67)(	50.46)(	64.43)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	807.00	807.00	824.50
	STORAGE	63.	63.	1569.
	OUTFLOW	0.	0.	11827.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	809.27	0.00	149.	126.	0.00	18.50	0.00
.25	811.37	0.00	259.	433.	0.00	18.00	0.00
.50	813.84	0.00	399.	1015.	0.00	17.58	0.00
.65	815.02	0.00	482.	1365.	0.00	17.50	0.00
.80	816.00	0.00	559.	1782.	0.00	17.42	0.00
1.00	817.17	0.00	601.	2275.	0.00	17.33	0.00

APPENDIX B

INFORMATION SUPPLIED BY OTHERS

Confidential

ENGINEERING GEOLOGIC ASPECTS OF BARITE TAILINGS POND FAILURE "DRESSER NO. 4"

Washington County, Mo.

LOCATION: Secs. 10, 11, 14, and 15, T. 38 N., R. 3 E., Tiff Quadrangle

SIZE: 135 Acres (tailings pond - 75 acres, clear water lakes - 60 acres; dam inventory no. 30470). Area estimates based on topographic maps and aerial photography.

HEIGHT: Approximately 50 feet at point of failure, across a southward flowing valley.

GEOLOGIC SETTING:

The tailings pond is underlain by the Potosi dolomite, a massive, pinnacled Cambrian-aged Formation. The Potosi is densely jointed. Solution enlarged openings occur, but not extensive in this area. However, bedrock ranges from severly weathered to fresh unweathered exposures over short lateral distances. Regionally, the watersheds are gaining. No significant waterloss into cavernous bedrock occurs within the region.

Soil in the area consists of red clay, residual from the Potosi dolomite. Thickness of the residual soil ranges from 5 to more than 30 feet. Alluvial soil in stream valleys is generally thin, 5 to 15 feet, and consists of silt loam mixed with gravels. Soil that would be characteristic of the valley at the point of the dam failure could not be observed. It is likely this material consisted of silt loam mixed with gravel. The thickness could have ranged from 5 to perhaps 12 feet. Locally, it is also expected that bedrock outcrops were present within the stream channel.

CIRCUMSTANCES OF FAILURE:

The dam failed at approximately 2:00 a.m. on Friday, August 15th. Employees in the plant area reported that the failure was catastrophic. It was accompanied by an extremely loud noise. Plant Superintendent Gene Williams arrived on the scene at approximately 3:00 a.m. The first action taken was to notify people in the downstream area. Mr. Williams reported that when he was able to see the breached portion of the levee, the width of the breach was approximately the same as it is at the present, some 300 feet in width (MESA report 2_Sept. 75, Identification No. 23-00806).

The levee failure occurred on the upstream slope of the valley that formerly drained southward under the tailings pond. This valley is a tributary to a left bank tributary to Mill Creek. Drainage from the watershed upstream of the tailings pond had been diverted to the west side of the pond. The levee was breached on the northeastern corner of the tailings pond at the eastern end of the east-west portion of the levee. This places the break in the levee over the former stream channel.

With the break in the location described, the mud and water flowed upslope, that is up the valley and across Missouri State Hwy. E. Mud and water in excess of that which could be contained by the upslope portion of the watershed flowed around the western end of the tailings pond entering the left bank tributary to Mill Creek. This mud and water entered Mill Creek at Tiff

and eventually reached Big River. Since the break was upslope, much of the waste material was contained in that topographic setting. Thus, there was little damage as the result of flooding in the downstream area. However, a large volume of material has flowed from the tailings pond through the breached levee and has remained for several weeks on the upslope portion of the watershed outside the tailings pond.

The western portion of the levee suffered severe damage subsequent to the breach and outflow of pond mud and water. The embankment failure of the western levee consisted of rotational slides moving inward into the pond. Some small slips occurred on the outside slope of the levee. Extensive fractures parallel to levee alignment occurred along the crest of the levee. On 21 Aug. 1975, the western portion of the levee was in extreme jeopardy and could easily have failed with the further loss of additional mud westward into the by-pass drainageways that circumvented the tailings pond.

Some portions of the eastern levee also failed in a similar manner, but the destruction of the eastern levee was less extreme than that of the western levee. No damage occurred to the southern portion of the levee, this being the point at which the plant discharged into the tailings pond.

Approximate dimensions prior to failure at the point of failure were as follows:

1). Height, 50 feet.
2). Slope, 35 degrees (1½:1).
3). Crest width, 25 feet, (locally 20 feet).
4). Freeboard, 5 to 6 feet.
5). Hydraulic height between water and mud level within the lagoon and the clear water lake outside (north) of the levee, 35 feet.
6). Clear water lake depth, 10-15 feet.
7). Areal extent of the lagoon, 75 acres.

Water saturated mud was contained within the levee. A clear water lake existed north of the levee and covered the lower 10-15 feet of the levee. The levee was functioning as a filter drain between mud and water in the tailings pond and the receiving stream so that clear water could be discharged to the receiving tributary, or re-used in the plant operation. Water continually seeped through the levee. The primary control on the level of the clear water lake was a spillway on the diversion ditch designed so that water in the clear water lake did not flood Missouri State Hwy. E.

Mr. Williams, the Plant Superintendent reported that water level in the clear water lake would fluctuate no more than 2 or 3 feet. This fluctuation was not abrupt. It related more to the wetness of a particular season than to any sudden change. No significant water level fluctuations were reported to have occurred prior to dam failure. As indicated by Dr. Larry Fellows (pers. comm.), no detectable seismic related events, natural or man-made, were recorded by the seismographic station located at French Village at the time of failure (Otto Nuttli, St. Louis University, St. Louis, Mo.).

Mr. Williams, the Plant Supertindent had reported that trucks had passed over the dike as late as 11:00 p.m. on the evening prior to the dam failure. Operations prior to dam failure appear to have been routine, including no observance of any indication that failure would occur at this or any point in the dike.

The levee has been constructed of gravel as a by-product from the plant operation. Attached laboratory data indicates the size and sorting of the gravel material. Almost all of the gravel is less than three-quarter inch in size, but there is less than 10 percent clay and silt (fig. 1 and 2). Typical operations in the construction of a gravel levee for a tailings pond involve the hauling of gravel along the crest of the levee. The gravel is dumped either into the interior of the pond, or onto the exterior portion of the levee slope. Only the width of the levee traveled by the truck receives compaction, thus, the average compacted width of the levee is likely to be no more than 20 or 25 feet. Some levees in Washington and Jefferson Counties have a compacted width of 12 to 15 feet, others 35 to 40 feet. A sample of gravel obtained on the eastern face (west-facing) of the breached Dresser no. 4 levee had a 90 pounds per cubic foot unit dry weight (fig. 3). This lower than normal density of compacted gravel could be attributed to the lower specific gravity that would be expected of chert fragments that are formed as a secondary or residual product from weathering. Specific gravities of the chert range from 2.54 to 2.56. The density of mud contained within the pond would be expected to exceed this (H. M. Wharton, 1972; Barite Ore Potential, Mo. Geol. Survey, RI No. 53.)

It can be shown from engineering calculations (Heacler, pers. comm.) that a gravel levee of the dimensions at the Dresser Dam site, if well compacted throughout the lateral extent of the levee, could have a factor safety of 1.5 relative to the impounded mud and water. However, common construction practices of tailings ponds dams as described above result in only the central portion of the levee being compacted. The front portion (interior facing) of the levee is made up of end-dumped gravel intermixed with mud (figs. 4 and 5). The back portion (outside slope) of the levee consists of gravel that has rolled over the backslope after having been dumped on the crest of the levee. Therefore, there is only one-half, perhaps on some levees only one-fourth of a dam relative to actual design needs for retardation of impounded mud and water.

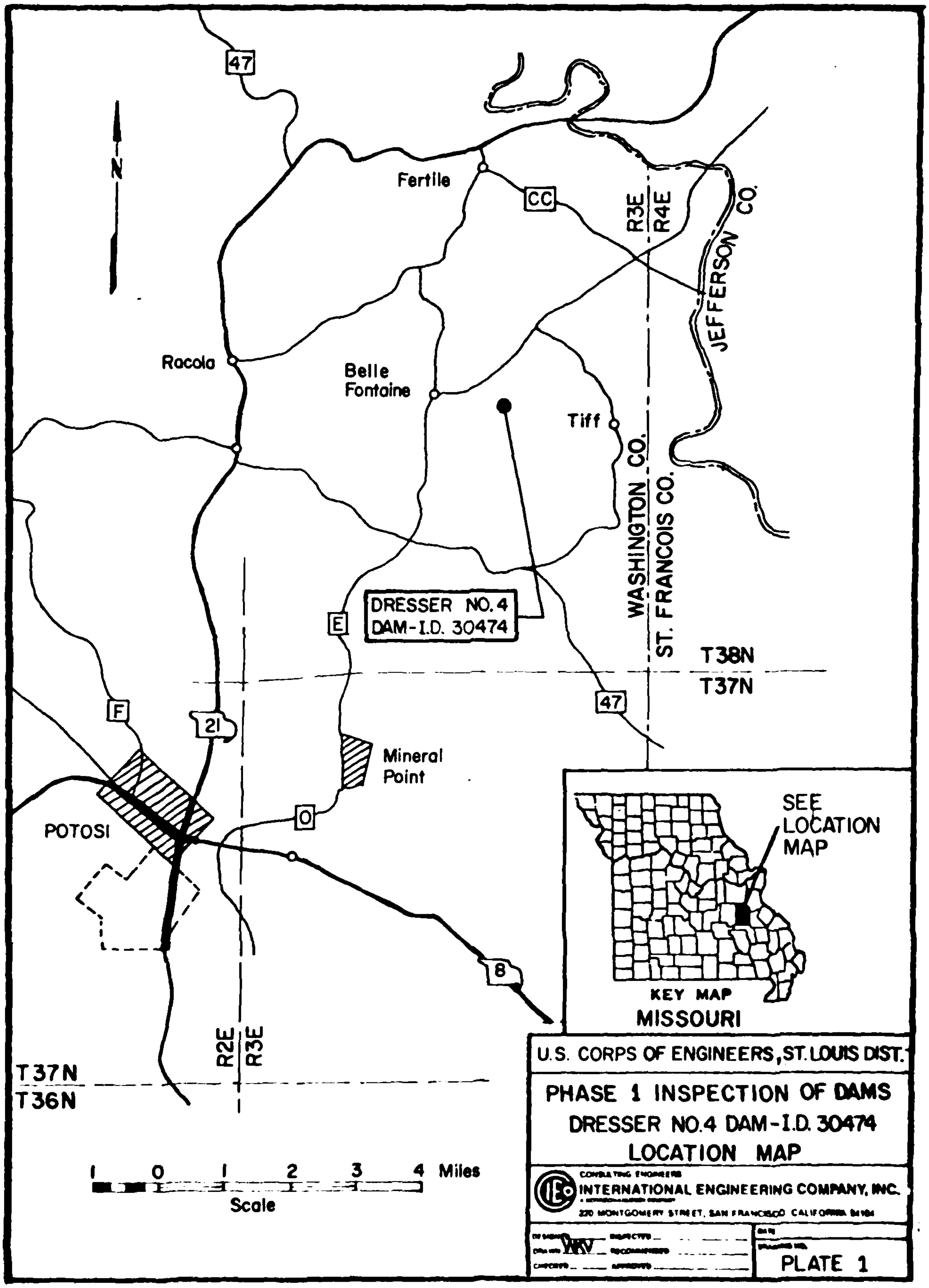
Common practice is to construct a starter dam at the main portion of the levee. This starter dam consists of compacted earth. Again, if common practices are followed, the gravels from the plant are dumped on the front slope of the starter dam into the mud discharged from the plant. However, the starter dam commonly extends only across the downstream portion of a tailings pond across the valley bottom. The remainder of a levee of a tailings pond commonly is made up only of gravels from the plant operation. These gravels are dumped on the natural soil materials. The gravels are not placed on a sound foundation constructed for the purposes of a water detention structure. It is likely, although not substantiated, at the area of failure on the Dresser Dam, the gravel levee rested on natural soil material. In fact a portion of these gravels could have been end-dumped onto mud and water that had backed up the valley from the main dam. It could have been a situation in which a levee had to be constructed across the upper portion of the tailings pond to retard the movement of mud and water upstream and thereby flooding the highway. Thus, if common construction practices typical of barite tailing ponds are followed, the pond levee at the point of failure consisted o

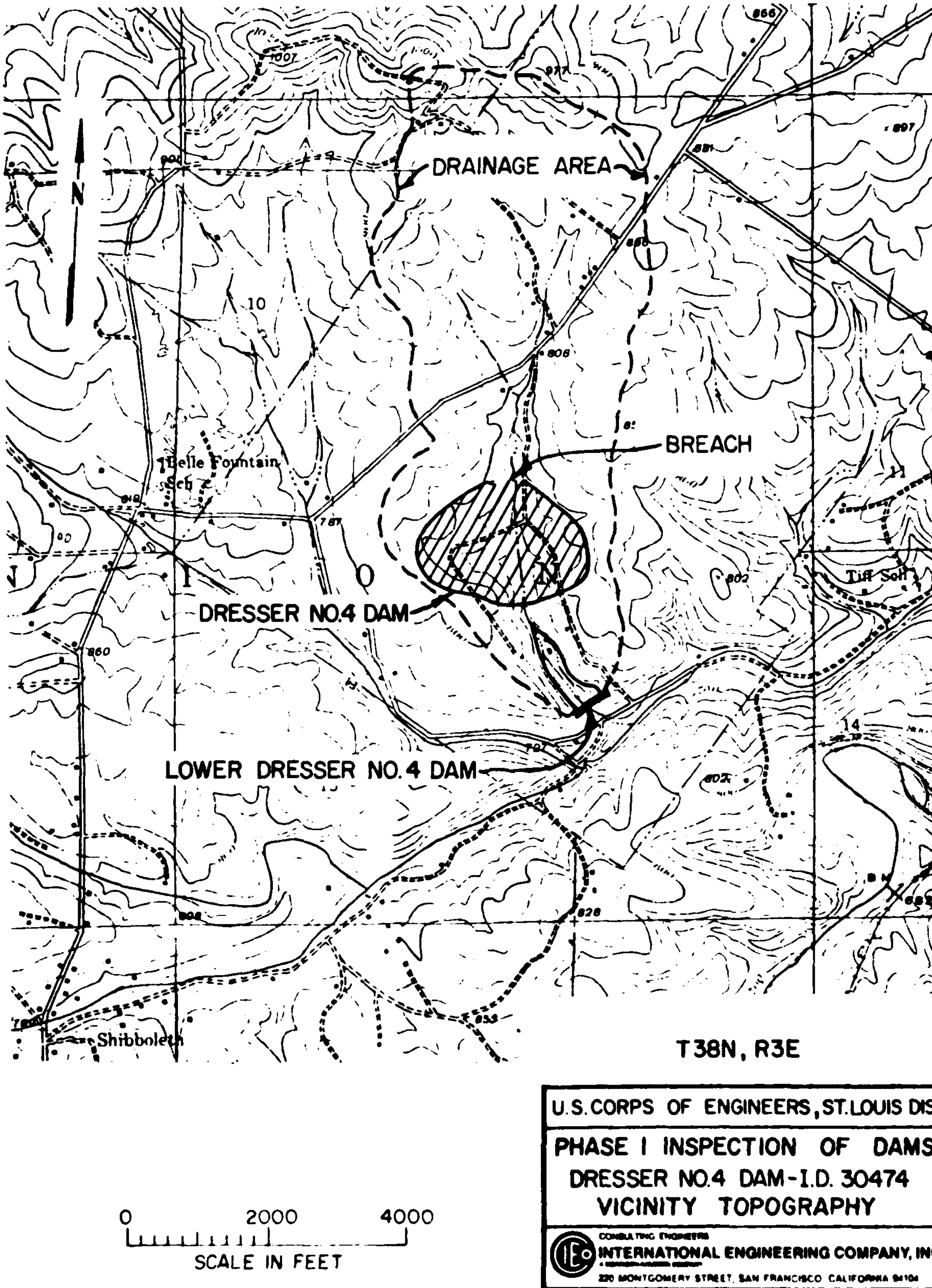
of gravel resting on mud, organic material, and alluvial soil deposits. The levee would have been compacted only in the center 20 or 25 foot section. The front slope of the levee would have been made up of gravel mixed with mud, and the back slope of the levee would have consisted of loose gravel, water saturated in the lower 15 to 30 feet.

The construction practices described above violate all common procedures followed in the construction of dams within the State of Missouri. It has been my observation that very few engineers or very few contractors either acting independently or together would recommend the construction of a dam if the foundation was not placed on sound subsoil or bedrock prepared for purposes of impounding water, mud, or sewage. Usually core trenches are constructed. The dams are compacted throughout the extent of the structure in a uniform manner, and not limited to the centerline travelled by machinery. If the dam is to be over 40 or 50 feet some effort is given to stabilization of back slopes such as by berms. If berms are used they consist of well compacted material, not loose debris dumped from the dam crest.

The practices described in this report as commonly used in the construction of barite dams are those which could lead to failures by a massive foundation failure. This could occur on the natural soil materials. It also could result due to the mixture of gravel and mud in the base of the foundation. There could possibly be additional factors which could be considered that could have contributed to or have been an independent cause of levee failure. This would include slides within the levee as the result of an admixture of mud and clay. The Dresser levee failure could have been a foundation failure, a rotational slide failure if a quantity of mud was incorporated in the dike, a shear failure in gravel of low strength or combination thereof. If the Dresser No. 4 dam was built using procedures common to construction of barite tailings dams, it rested on an inadequate foundation and had inadequate strength and density to contain water and muds of clay size soil and barite. Assuming a foundation condition typical of barite dams a foundation failure is the likely choice. If evidence remains subsequent to the damage caused by the failure, exploration could assist in defining the cause more precisely.

Dr. J. Hadley Williams, Chief
Applied Engineering & Urban Geology
Missouri Geological Survey
September 22, 1975


N
47
Fertile
CC
R3E
R4E
JEFFERSON CO.
Racola
Belle Fontaine
Tiff
WASHINGTON CO.
ST. FRANCOIS CO.
DRESSER NO. 4
DAM-I.D. 30474
E
T38N
T37N
47
F
21
Mineral Point
POTOSI
O
8
SEE LOCATION MAP
KEY MAP
MISSOURI
R2E
R3E
T37N
T36N
1 0 1 2 3 4 Miles
Scale
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.
PHASE 1 INSPECTION OF DAMS
DRESSER NO.4 DAM-I.D. 30474
LOCATION MAP
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104
PLATE 1



0 2000 4000

SCALE IN FEET

U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

PHASE I INSPECTION OF DAMS
DRESSER NO.4 DAM - I.D. 30474
VICINITY TOPOGRAPHY

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104

PLATE 2

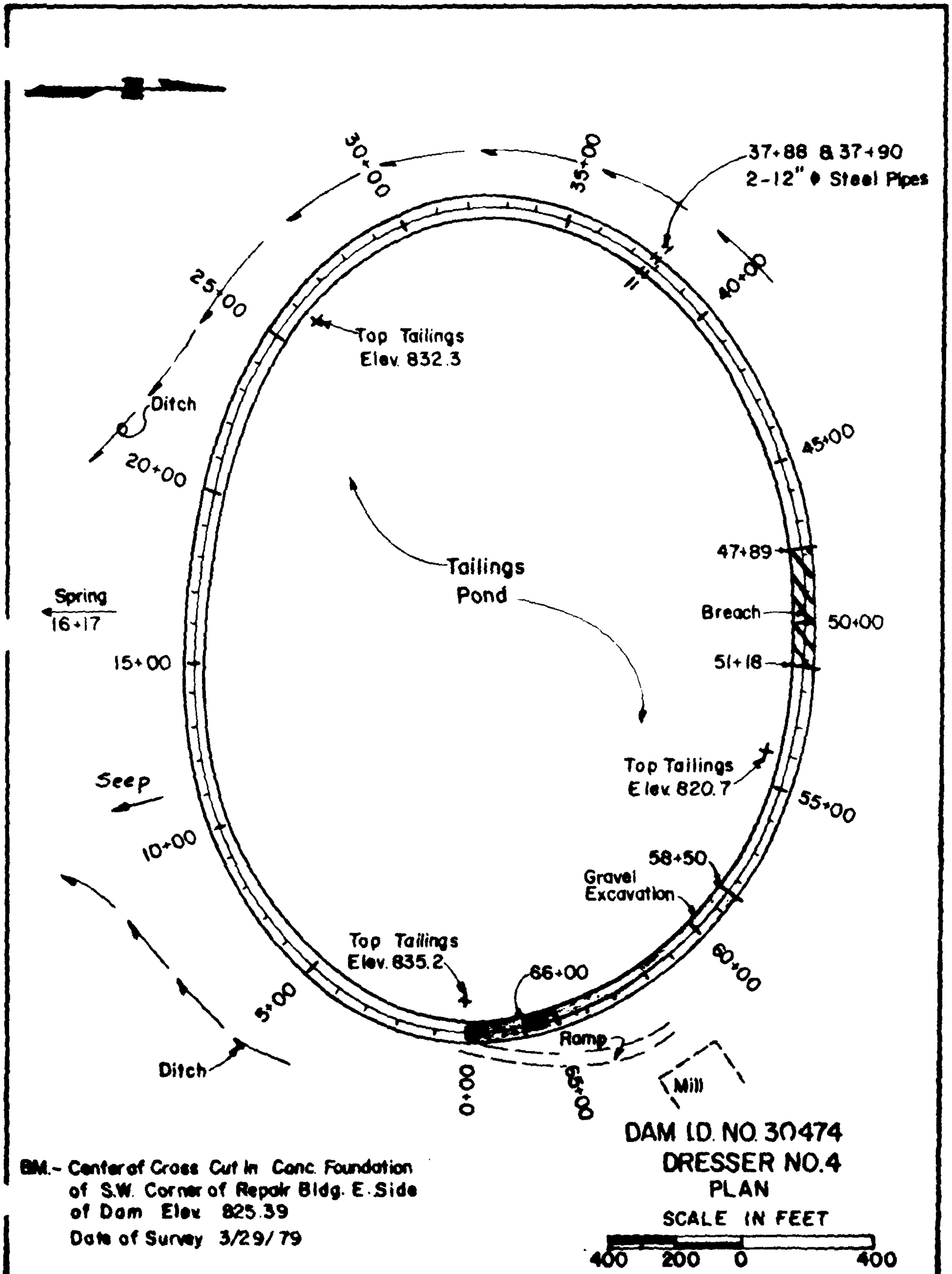
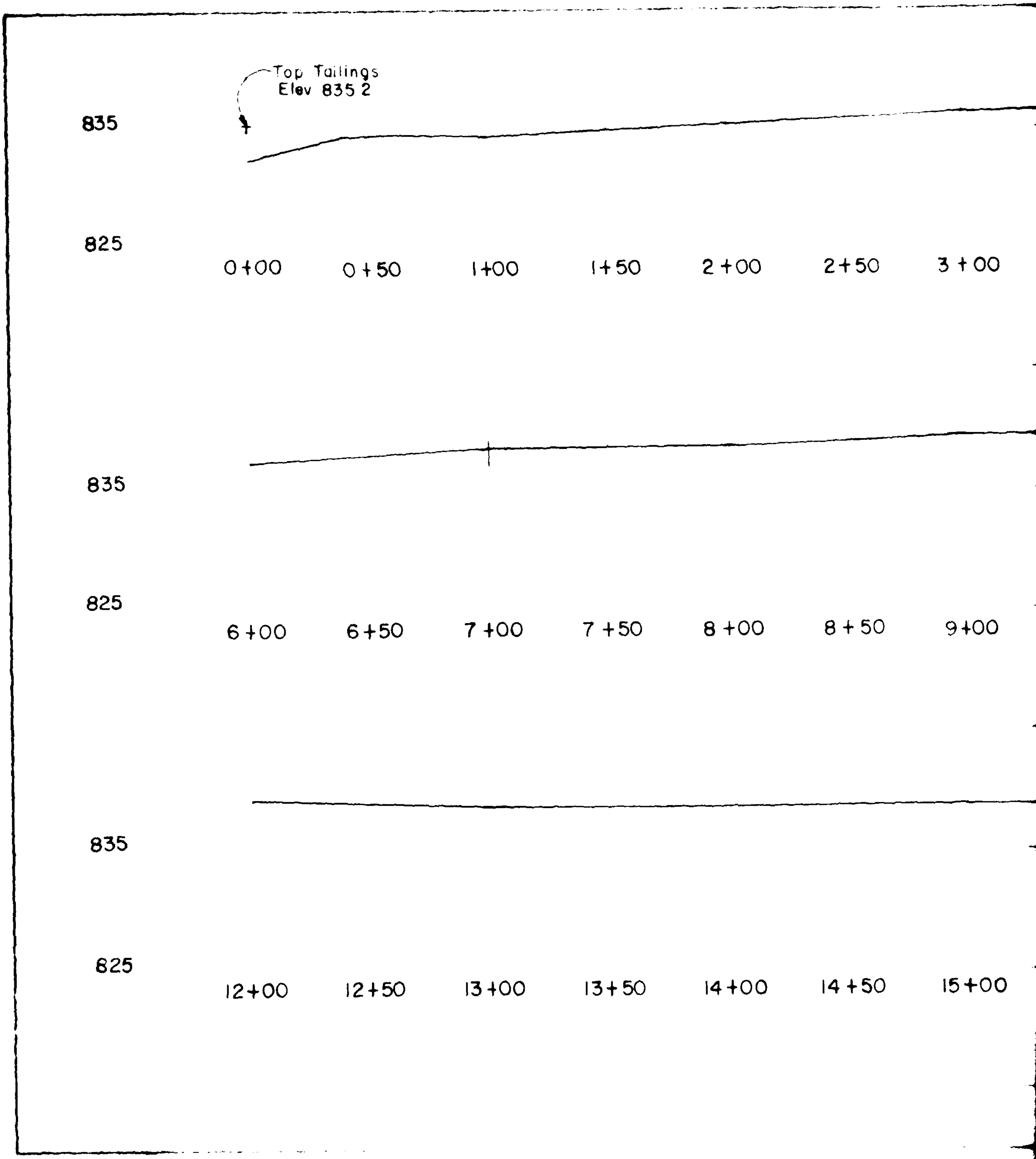

37+88 & 37+90
2-12" ϕ Steel Pipes
30+00
35+00
40+00
25+00
Top Tailings
Elev. 832.3
Ditch
20+00
45+00
Tailings
Pond
47+89
Breach
50+00
51+18
Spring
16+17
15+00
Top Tailings
Elev. 820.7
Seep
55+00
10+00
58+50
Gravel
Excavation
Top Tailings
Elev. 835.2
60+00
66+00
5+00
Ramp
Ditch
0+00
65+00
Mill
DAM I.D. NO. 30474
DRESSER NO.4
PLAN
SCALE IN FEET
400 200 0 400
BM.- Center of Cross Cut in Conc. Foundation
of S.W. Corner of Repair Bldg. E. Side
of Dam Elev. 825.39
Date of Survey 3/29/79

PLATE 3


Top Tailings
Elev 835 2
835
825
0+00
0+50
1+00
1+50
2+00
2+50
3+00
835
825
6+00
6+50
7+00
7+50
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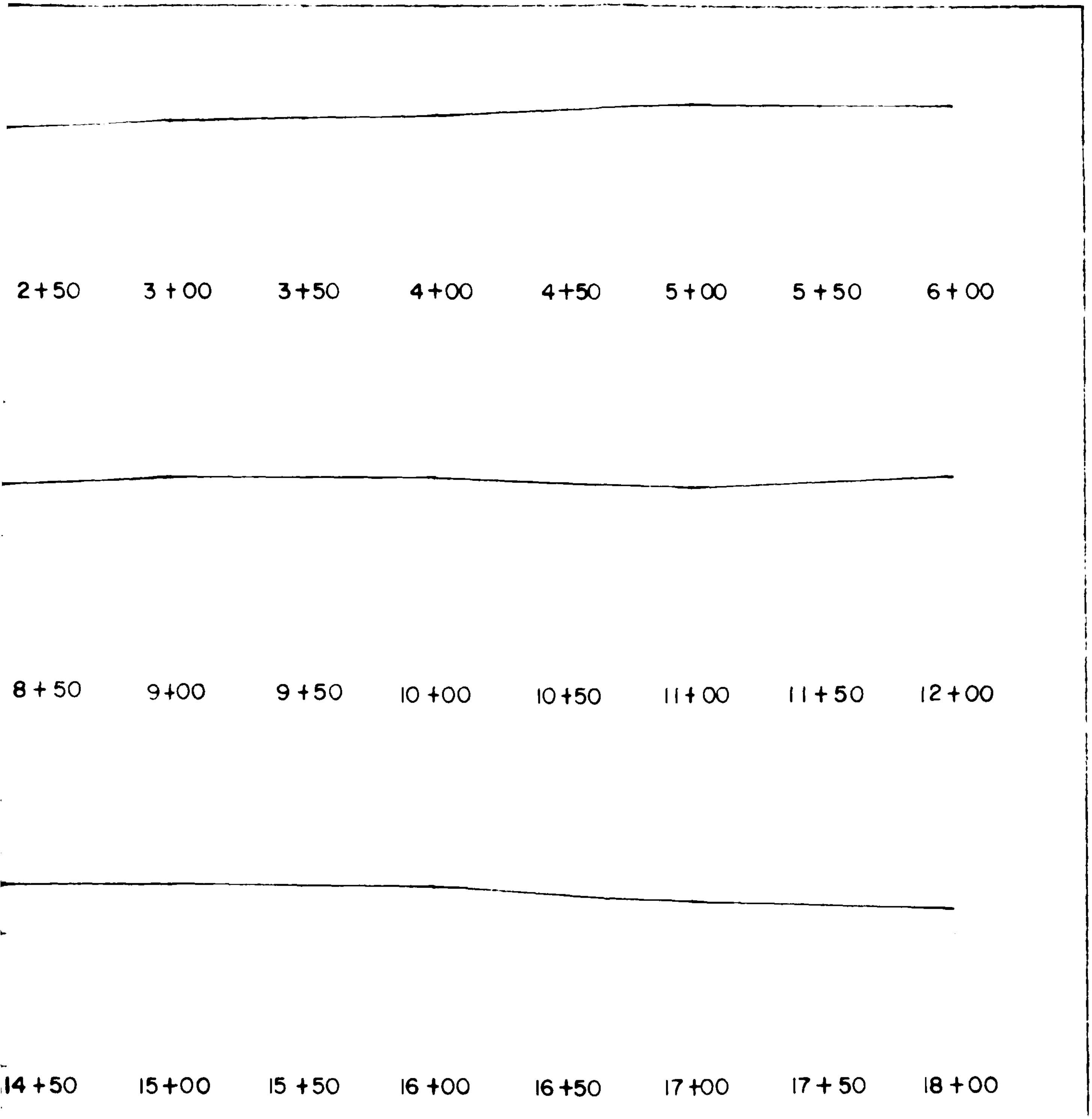
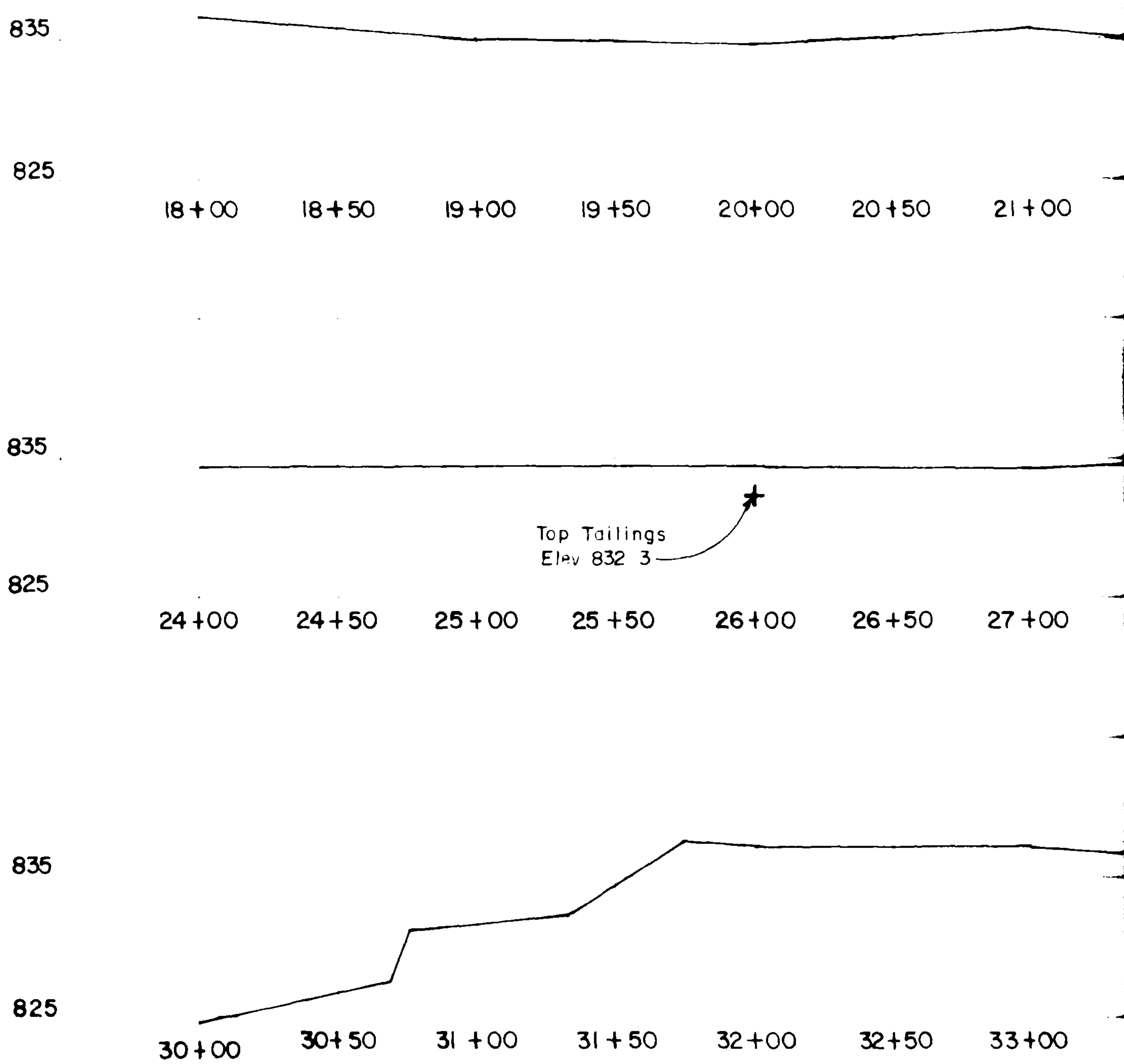
14+00
14+50
15+00



DAM I.D. NO. 30474
DRESSER NO. 4

DAM PROFILE

PLATE 4A



835
825
18+00
18+50
19+00
19+50
20+00
20+50
21+00
835
825
Top Tailings
Elev 832 3
24+00
24+50
25+00
25+50
26+00
26+50
27+00
835
825
30+00
30+50
31+00
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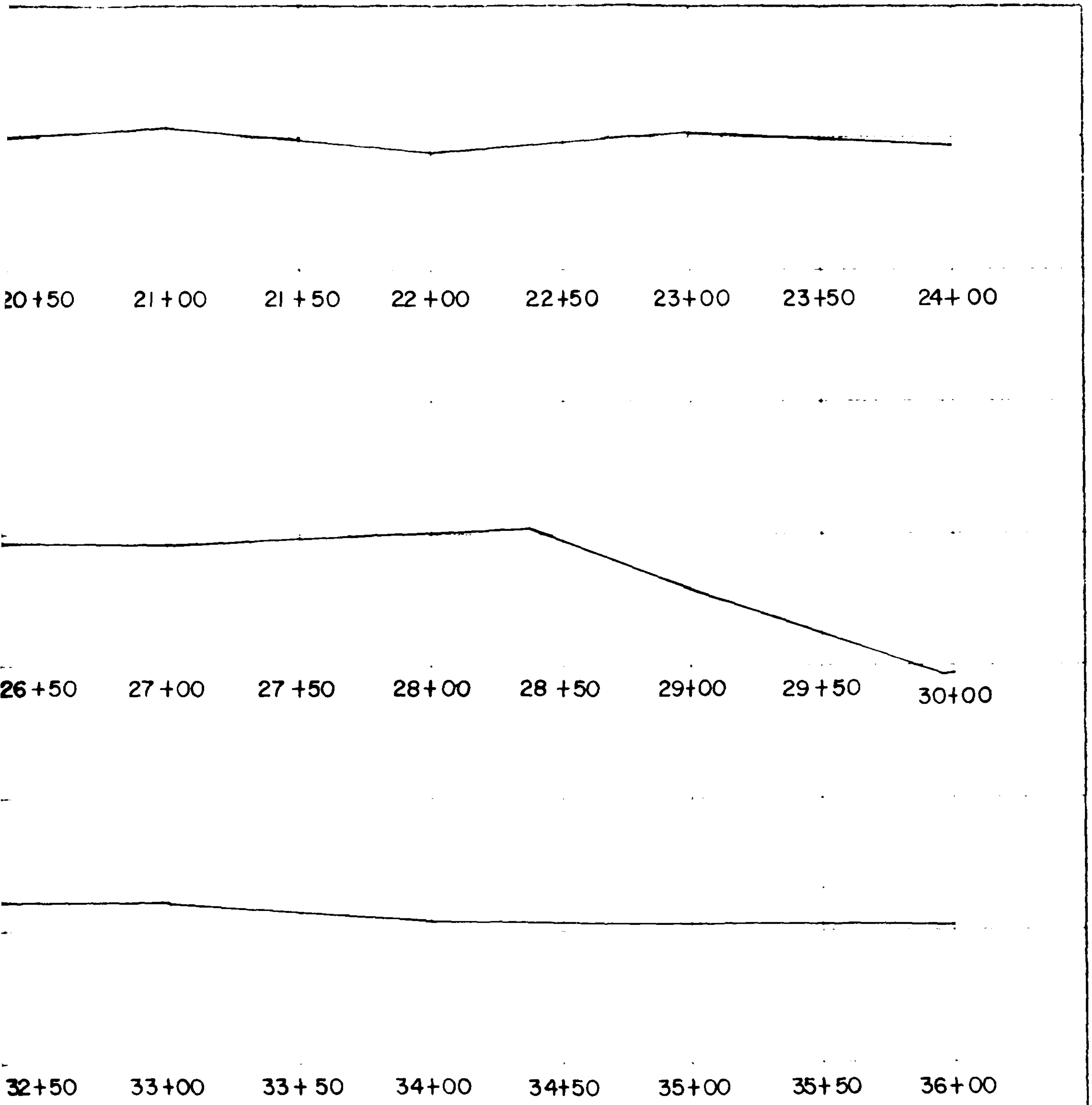
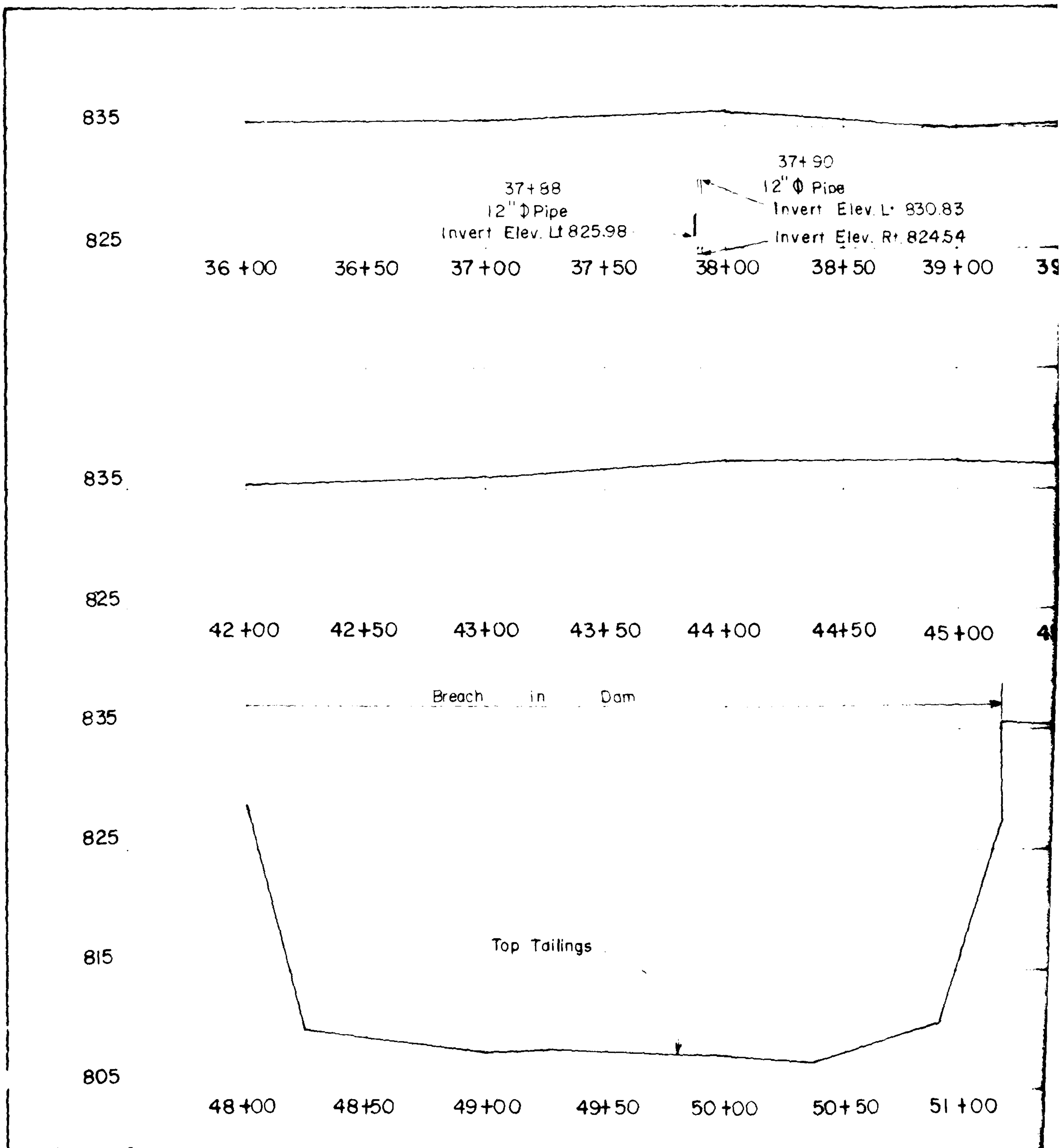
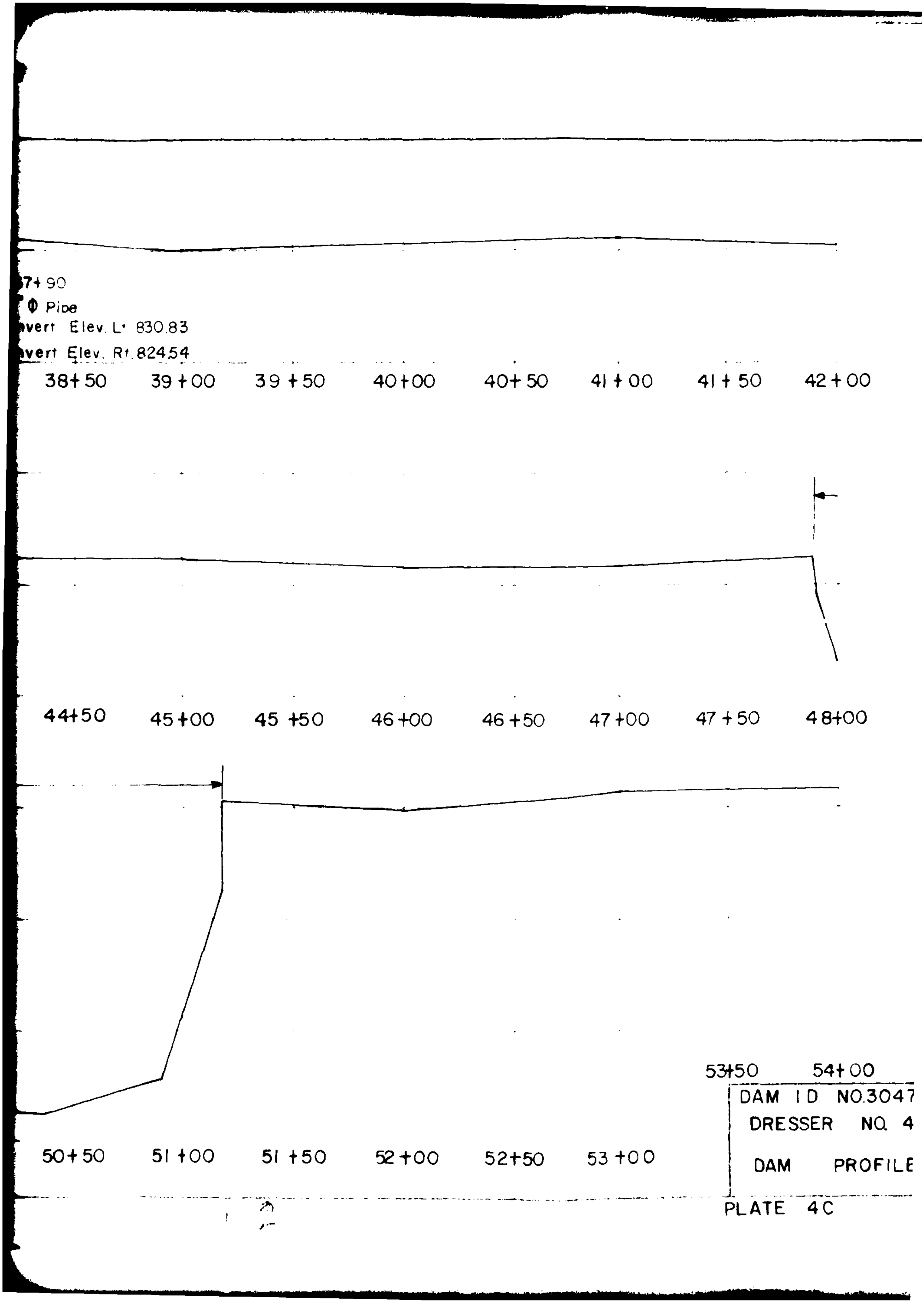
32+00
32+50
33+00



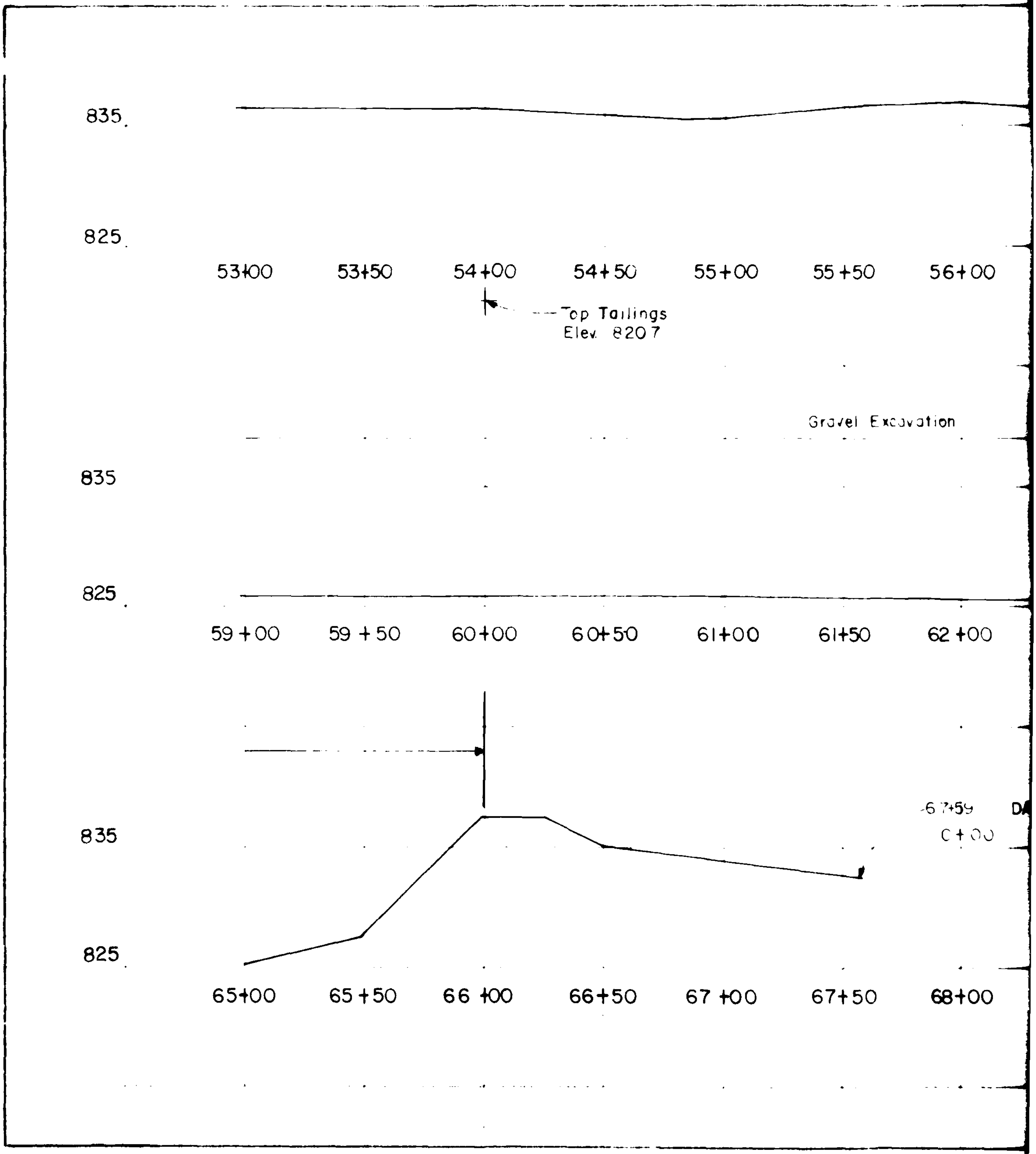
DAM I.D NO. 30474
DRESSER NO. 4
DAM PROFILE

PLATE 4B


835
825
36 +00
36+50
37 +00
37 +50
38+00
38+50
39 +00
37+88
12" Φ Pipe
Invert Elev. Lt 825.98
37+90
12" Φ Pipe
Invert Elev. L. 830.83
Invert Elev. Rt. 824.54
835
825
42 +00
42+50
43+00
43+50
44 +00
44+50
45 +00
Breach in Dam
835
825
815
805
Top Tailings
48 +00
48+50
49+00
49+50
50 +00
50+50
51 +00



7+ 90
Φ Pipe
vert Elev. L. 830.83
vert Elev. Rt. 824.54
38+50
39+00
39+50
40+00
40+50
41+00
41+50
42+00
44+50
45+00
45+50
46+00
46+50
47+00
47+50
48+00
50+50
51+00
51+50
52+00
52+50
53+00
53+50
54+00
DAM I.D. NO.3047
DRESSER NO. 4
DAM PROFILE
PLATE 4C


835
825
53+00
53+50
54+00
54+50
55+00
55+50
56+00
Top Tailings
Elev. 820.7
Gravel Excavation
835
825
59+00
59+50
60+00
60+50
61+00
61+50
62+00
67+59
0+00
835
825
65+00
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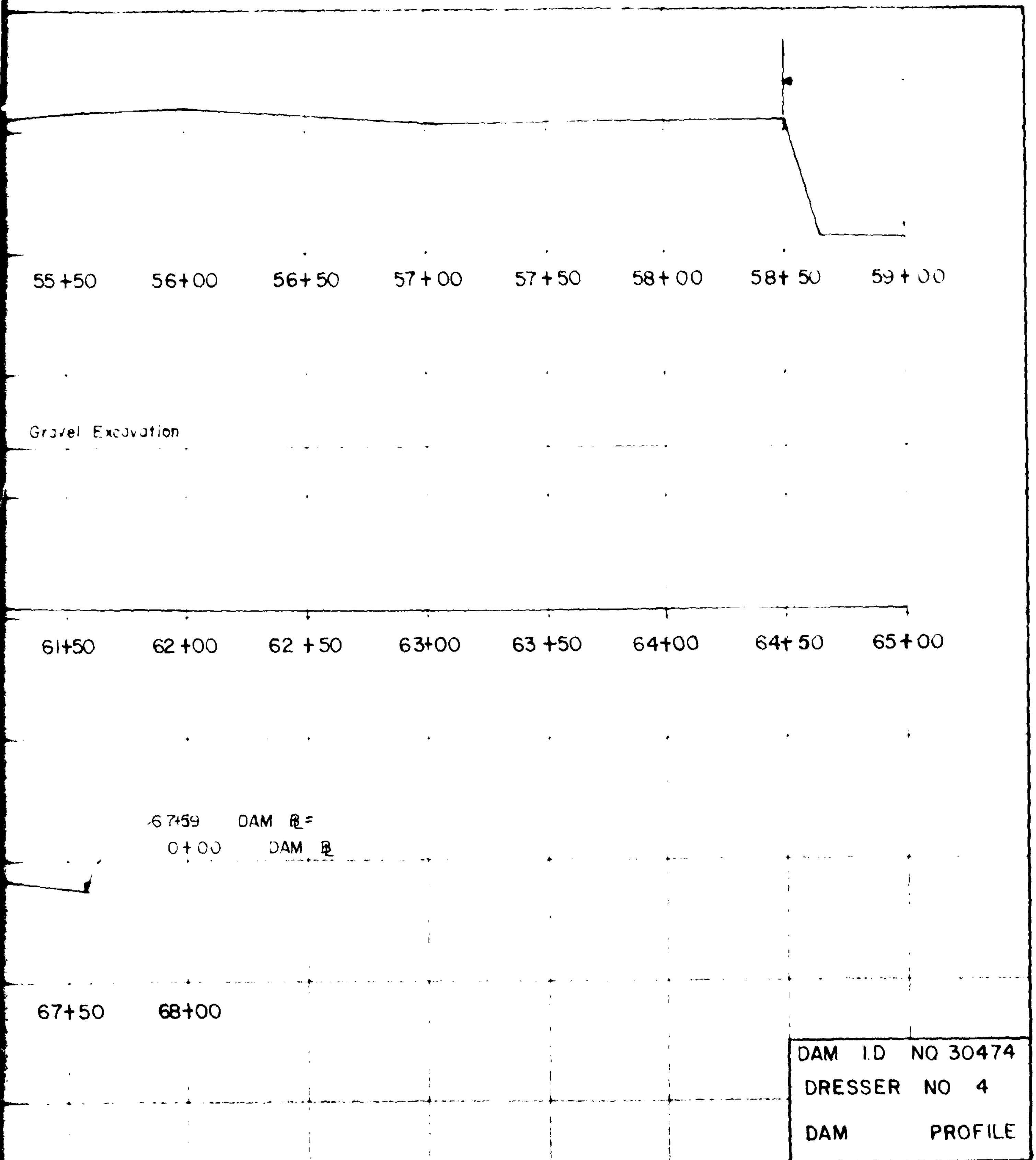
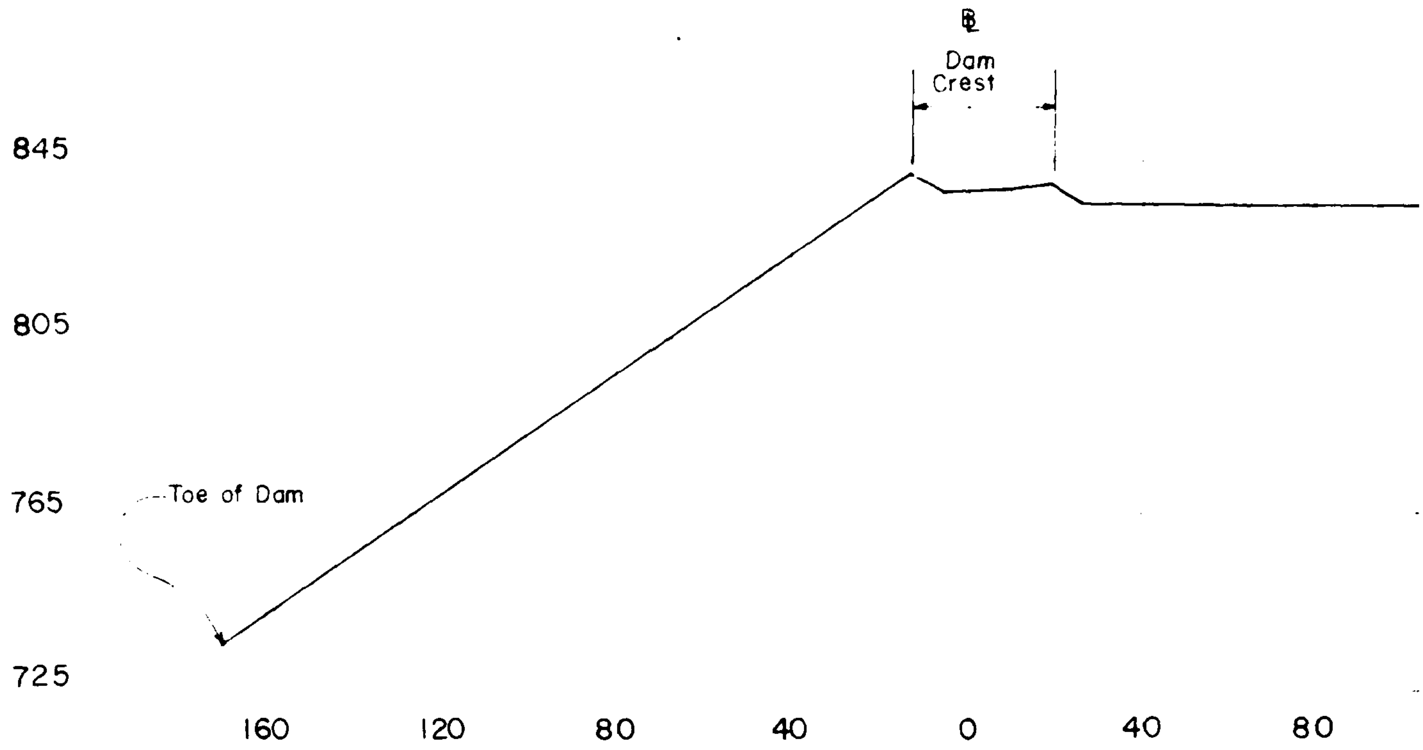
67+00
67+50
68+00



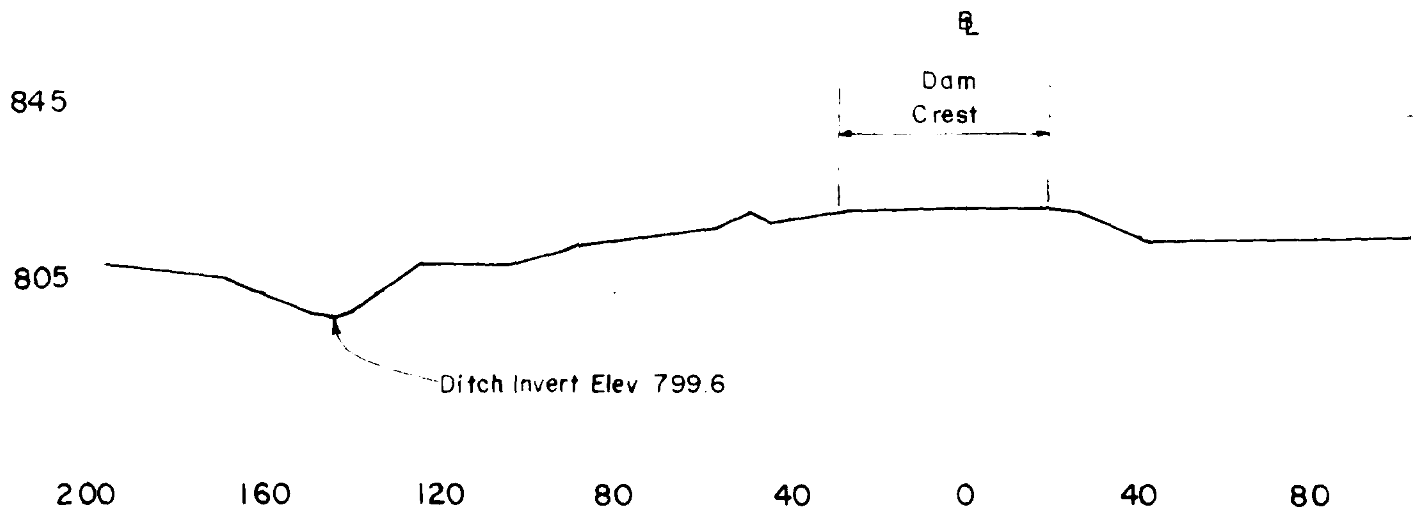
DAM I.D. NO. 30474
DRESSER NO. 4
DAM PROFILE

PLATE 4D

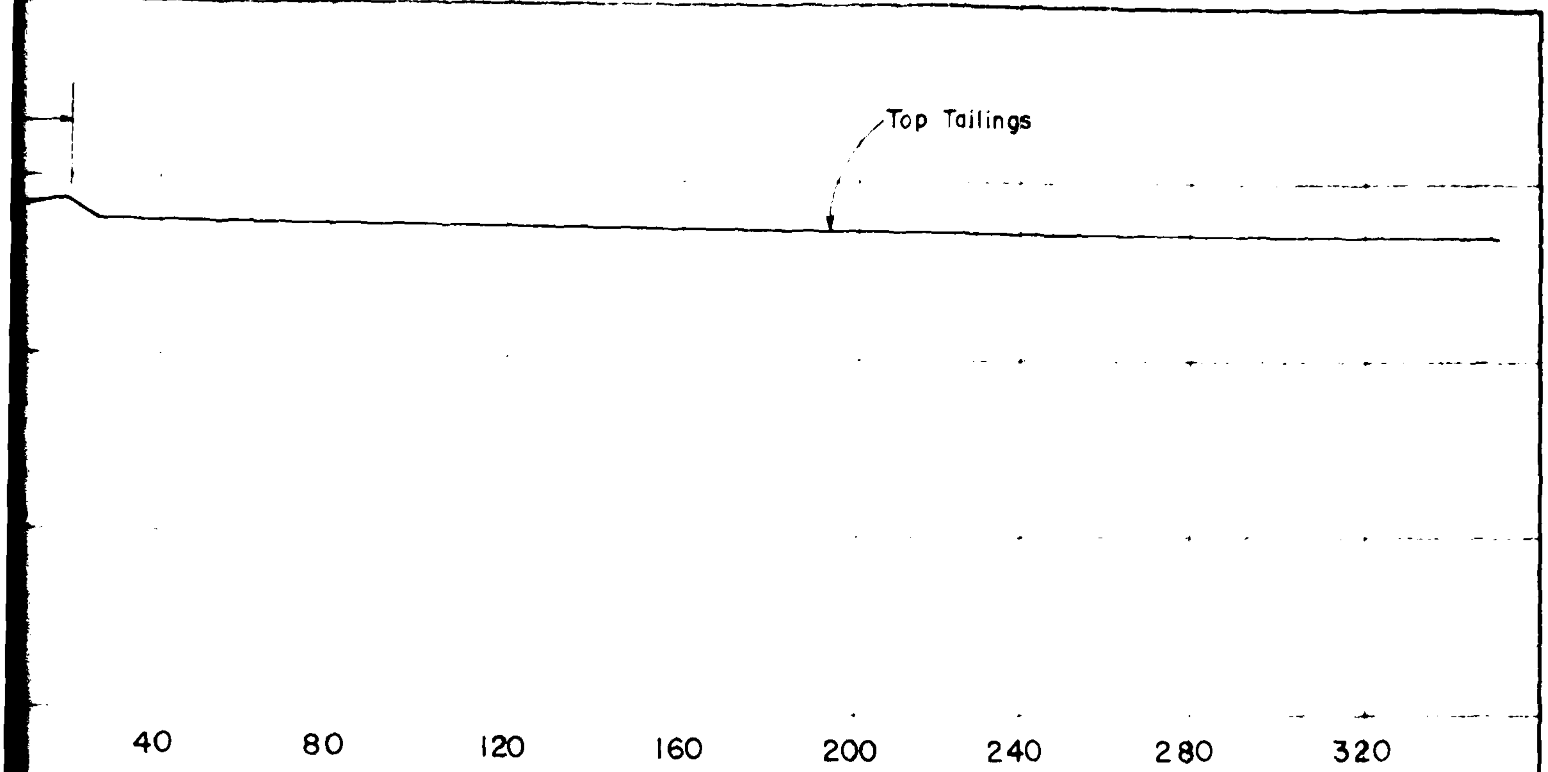
12



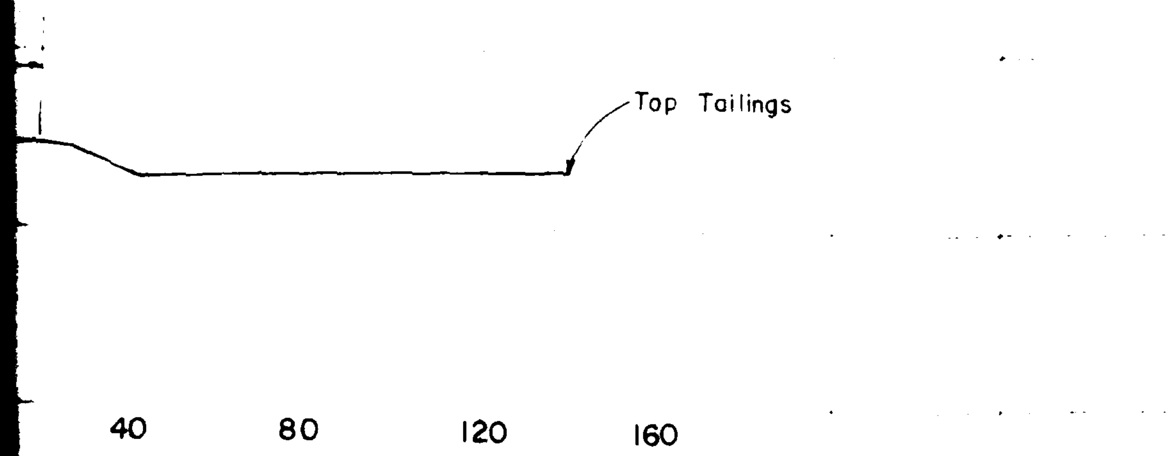
DAM CROSS-SECTION AT STA. 11+25



DAM CROSS-SECTION AT STA. 29+96



CTION AT STA. 11+25

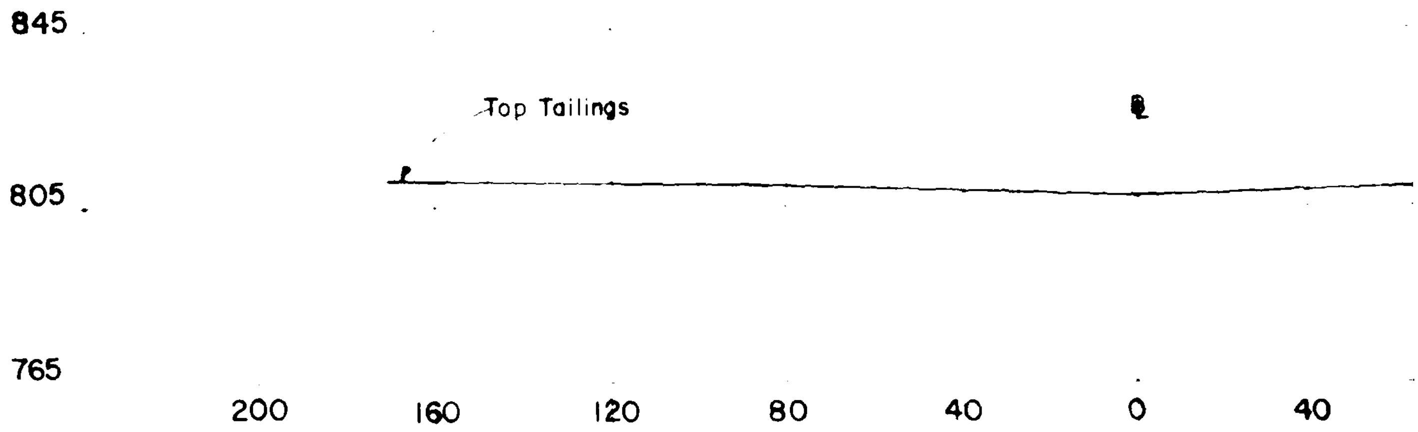


TION AT STA. 29+96

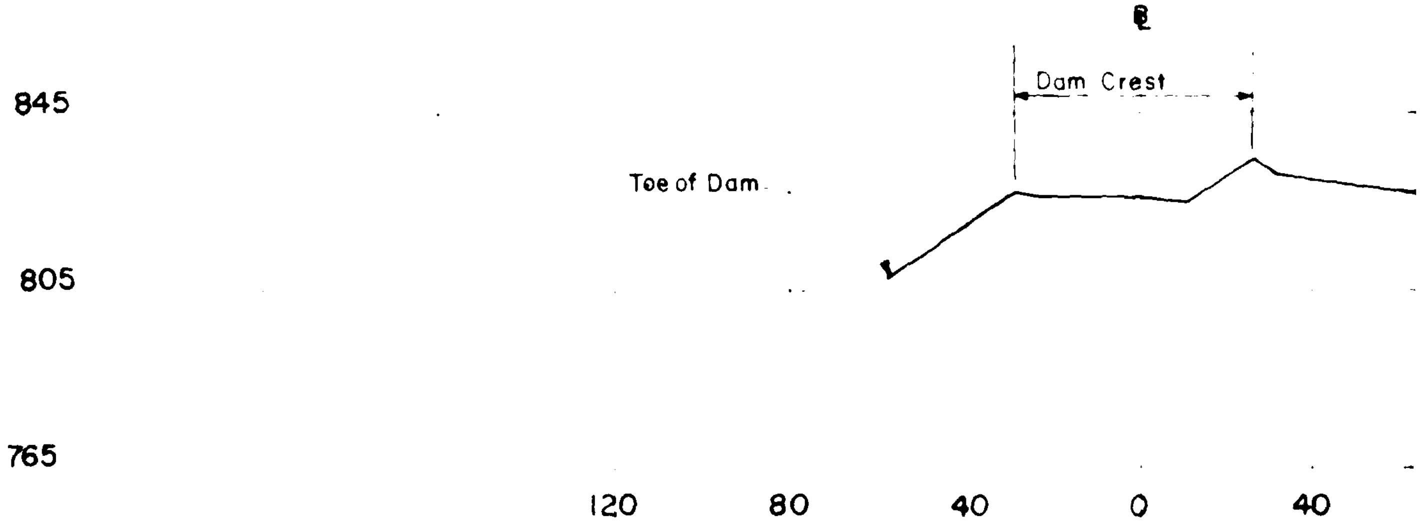
DAM I.D. NO. 30474
DRESSER NO. 4

DAM CROSS-SECTIONS

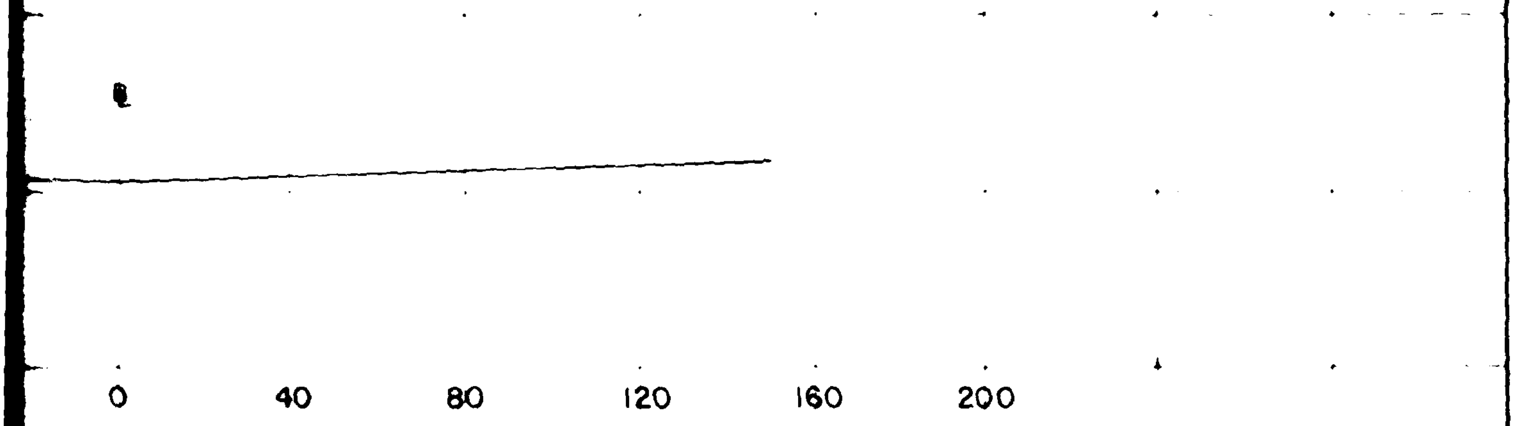
PLATE 5A



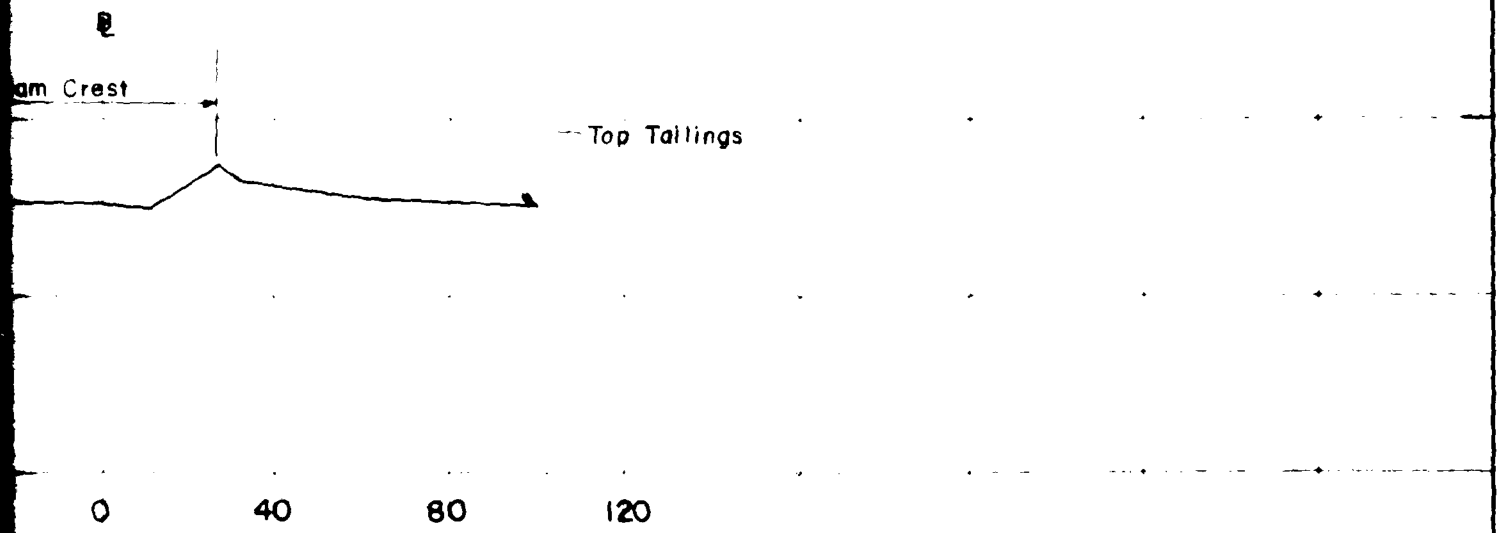
DAM CROSS-SECTION AT STA 49+30 (Br



DAM CROSS-SECTON AT STA. 59+00 (Grave



N AT STA 49+30 (Breached Area)

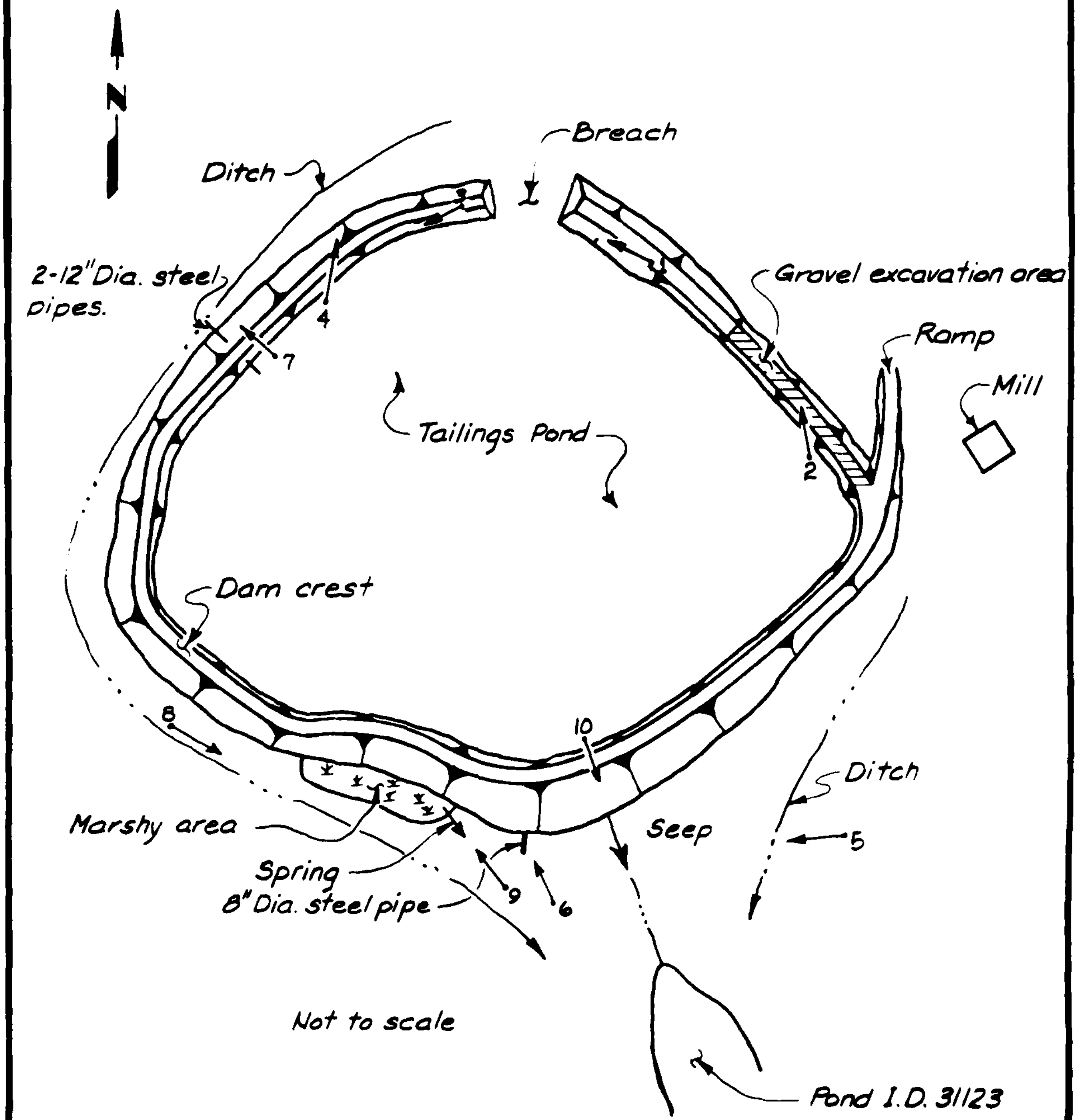


AT STA. 59+00 (Gravel Excavation Area)

DAM I.D. NO. 30474
DRESSER NO. 4

DAM CROSS-SECTIONS

PLATE 58



LEGEND:
4 → Photo number and view direction.

U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

PHASE I INSPECTION OF DAMS
DRESSER NO. 4 DAM - I.D. 30474
PHOTOGRPH LOCATION MAP

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.

PLATE 6

PHOTOGRAPH RECORD

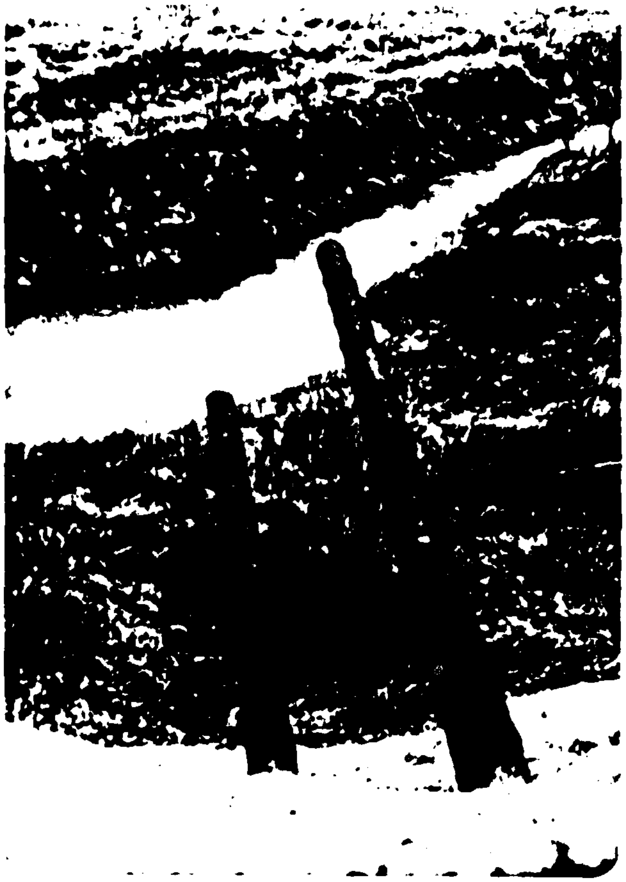
DRESSER NO. 4 DAM - I.D. NO. 30474

Photo No.	Description
1.	View northwest through breach in dam.
2.	Excavation of gravel from east side of impoundment. Tailings (left) are above the bench level.
3.	View westward of upstream face and crest of dam. Scarp also shown in this view.
4.	Crack in crest of dam at northwest end of impoundment.
5.	Downstream face of dam at south end of impoundment.
6.	8-inch diameter steel pipe at south end of impoundment.
7.	Outlet ends of the 12-inch diameter steel pipes at northwest end of impoundment and diversion ditch at toe of dam.
8.	View downstream of diversion ditch at southwest end of impoundment.
9.	Spring at toe of dam.
10.	Seepage at toe of dam and pond downstream formed by Lower Dresser No. 4 Dam (I.D. No. 31123).

1

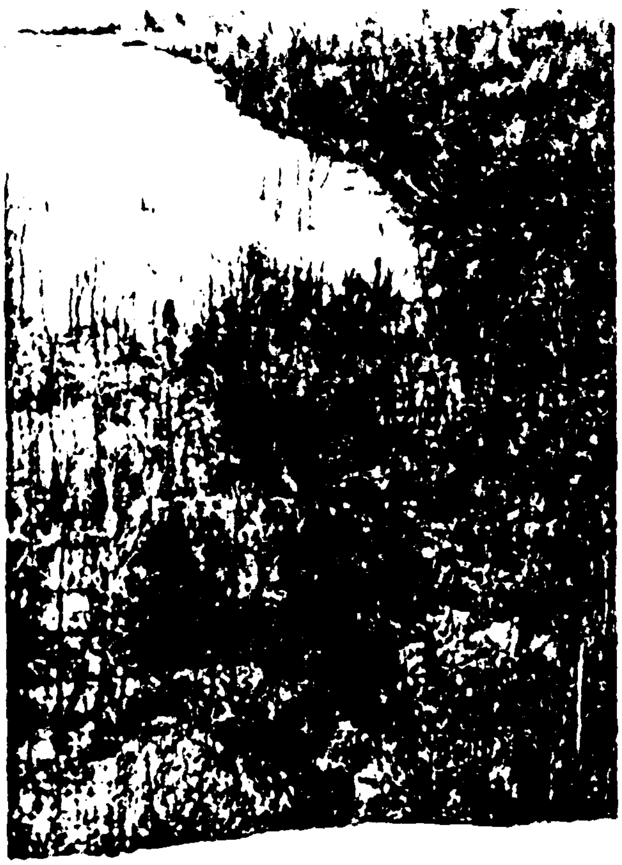
2

7



9

10



DA
FIL